Instruction / Service Manual
for

3245B
Inductance Analyser

Part No 9H3245B

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3245B INDUCTANCE ANALYZER

INSTRUCTION/SERVICE MANUAL

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Addendum to Manual 9H3245A 23.10.91

3245B

The 3245B is an improved version of the 3245A, having faster data handling speeds when operating under GPIB control. The maximum measurement rate is also increased, but in all other respects the specification and operation of the instrument are identical to the 3245A.

The following pages of the manual are affected by these changes:

Part 1 Operating Instructions

Specification Page 3:4 Section 3.01.09

Measurement speeds at 1kHz ac drive:

Normal	3.3/sec	approximately
Fast speed (reduced accuracy)	12/sec	approximately
Slow speed (improved resolution)	1/sec	approximately
At 100 Hz, Fast speed	6/sec	approximately
50 Hz, Fast speed	3.5/sec	approximately

Operation Page 4:4 BASIC FEATURES (7)

FAST speed makes approximately 12 readings per second, suited to initial settings of adjustable components.

Appendix A (GPIB) Page A:4 Add the following:

6. OPERATING SPEED

Set up time following receipt of a GPIB command varies with the particular instruction. Typical values are between 50 and 150 msec per command, allowing mixed command strings to be processed at approximately 10 instructions per second.

To trigger a measurement and output full data (4 strings) adds approximately 150 msec to the measurement times detailed in 3.01.09.

Appendix E (Handler Interface) Page E:4

Note (at top of page). Maximum speed in HOLD, with overloaded measurement, is increased from 20 to 51 per second.

3245B INDUCTANCE ANALYZER

THIS MANUAL COMPRISES TWO PARTS
WHICH ARE INDEPENDENTLY INDEXED

PART 1 OPERATING INSTRUCTIONS

PART 2 SERVICE/MAINTENANCE

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3245B INDUCTANCE ANALYZER

PART 1

OPERATING INSTRUCTIONS

MANUAL FOR THE PRECISION INDUCTANCE ANALYZER 3245

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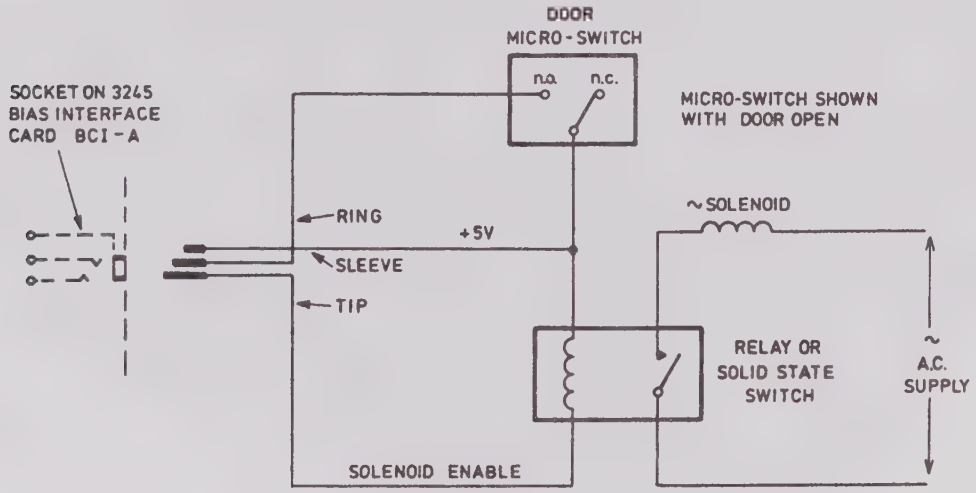
⚠ SAFETY INTERLOCK ⚠ FEATURE

(Applicable to Analyzers with software revisions 7.2 onwards)

For maximum operator safety, particularly on production-line testing, it is advisable to place the terminal fixture, for the inductor under test, within a housing with an interlocked door. The Bias Interface Card, (adjacent to the heat sink of the 3245) has a jack socket for use with a standard 3-pole 3.5mm Audio Jack. The connections this provides are shown below.



Only when the door is closed, and the micro-switch therefore made, can the dc bias be activated. At this time, the relay is energised, activating an ac supply for a solenoid which can be used to lock the door while the bias remains available.

The solenoid drive relay should have a 5-volt dc coil of resistance not less than 200 ohms. Diode coil protection is provided within the Bias Interface Card.

The door lock is activated when Bias ON is selected on the 3245. If the door switch or interlock lead is broken, the dc bias is inhibited.

IMPORTANT If the Interlock feature is not required, it is necessary to insert the 3.5mm Audio Jack, with the ring and sleeve connections linked, into the socket on the Bias Interface Card. Failure to do this will result in bias being inhibited, and the message ⚠ SAFETY INTERLOCK ⚠ being displayed.

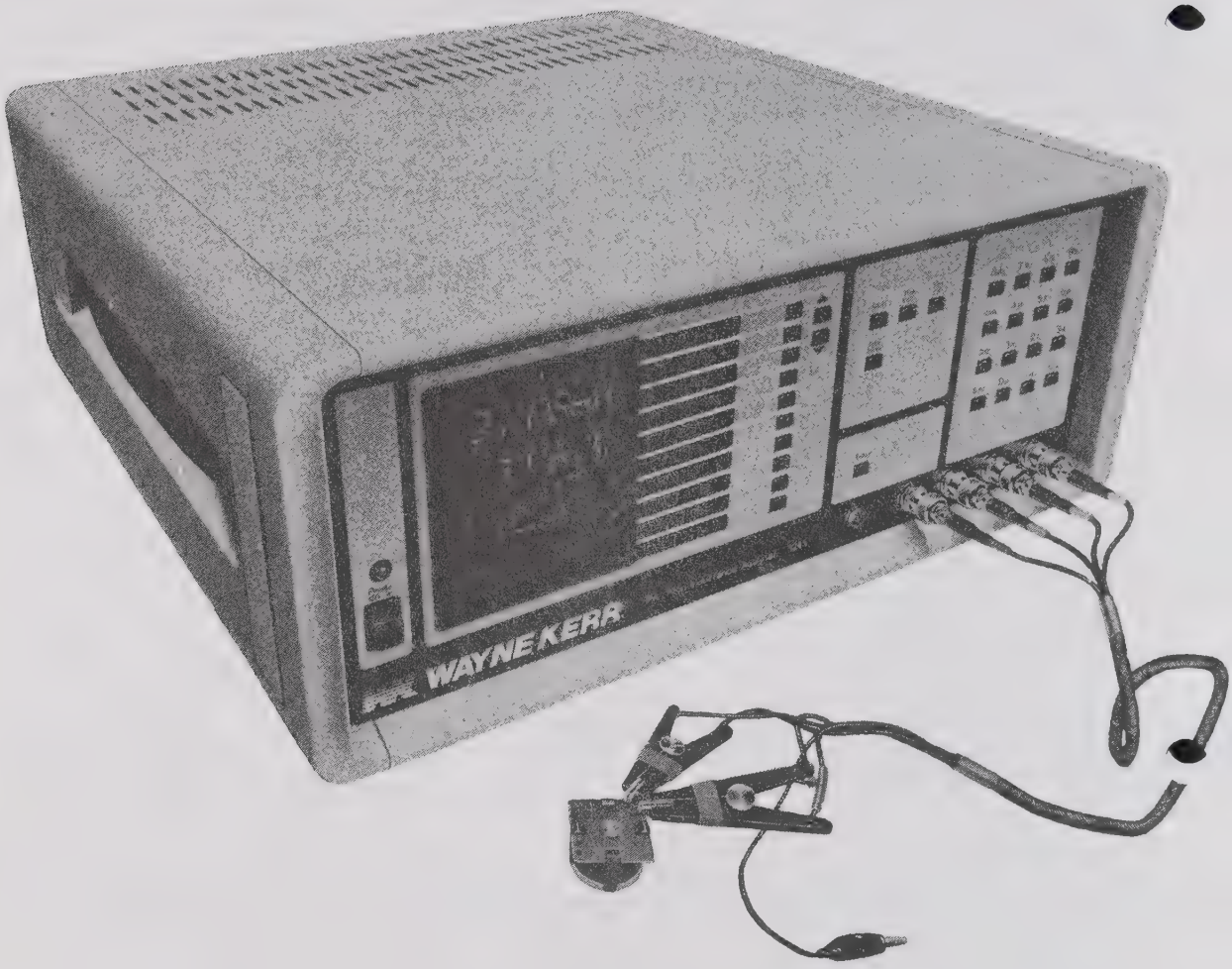
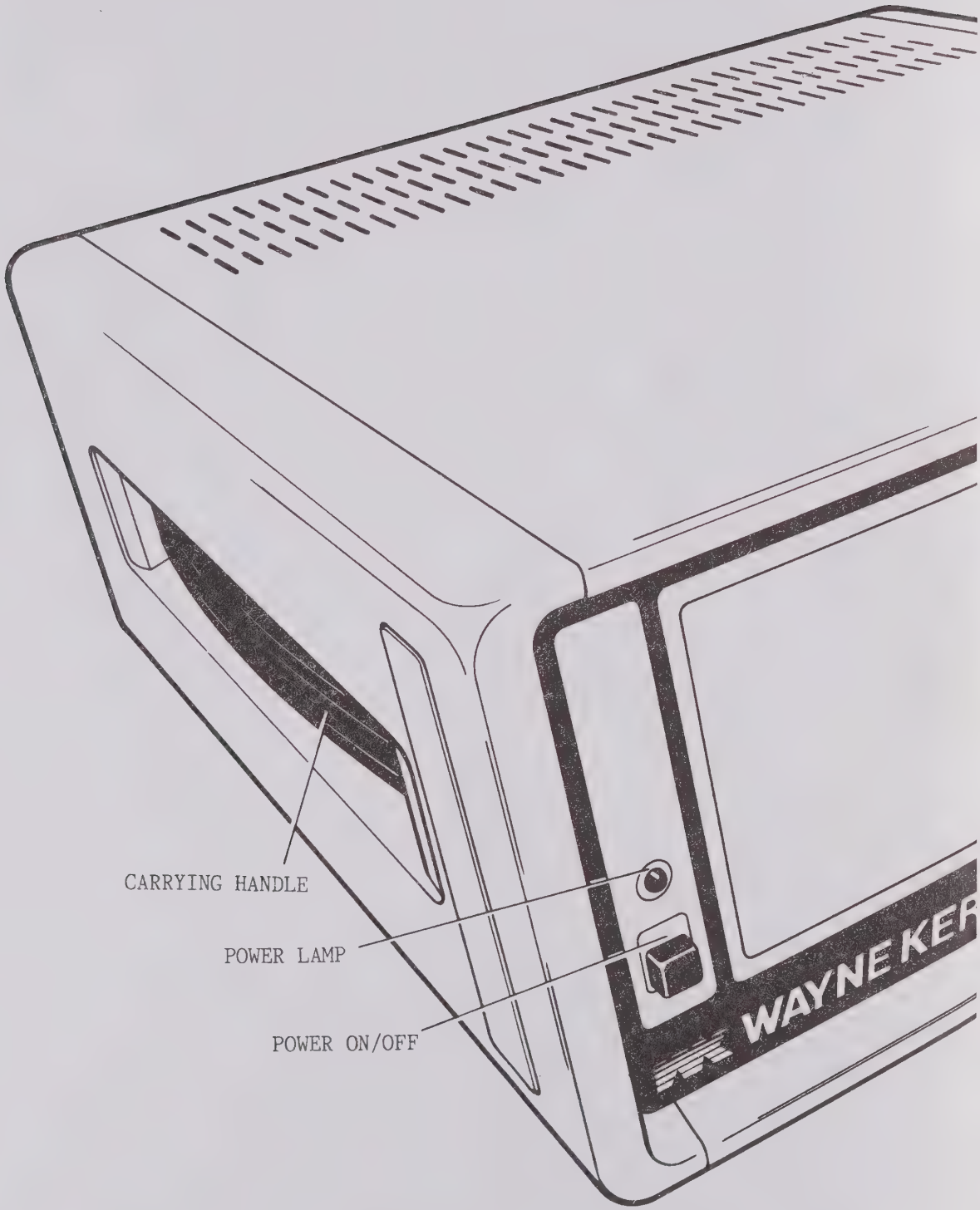
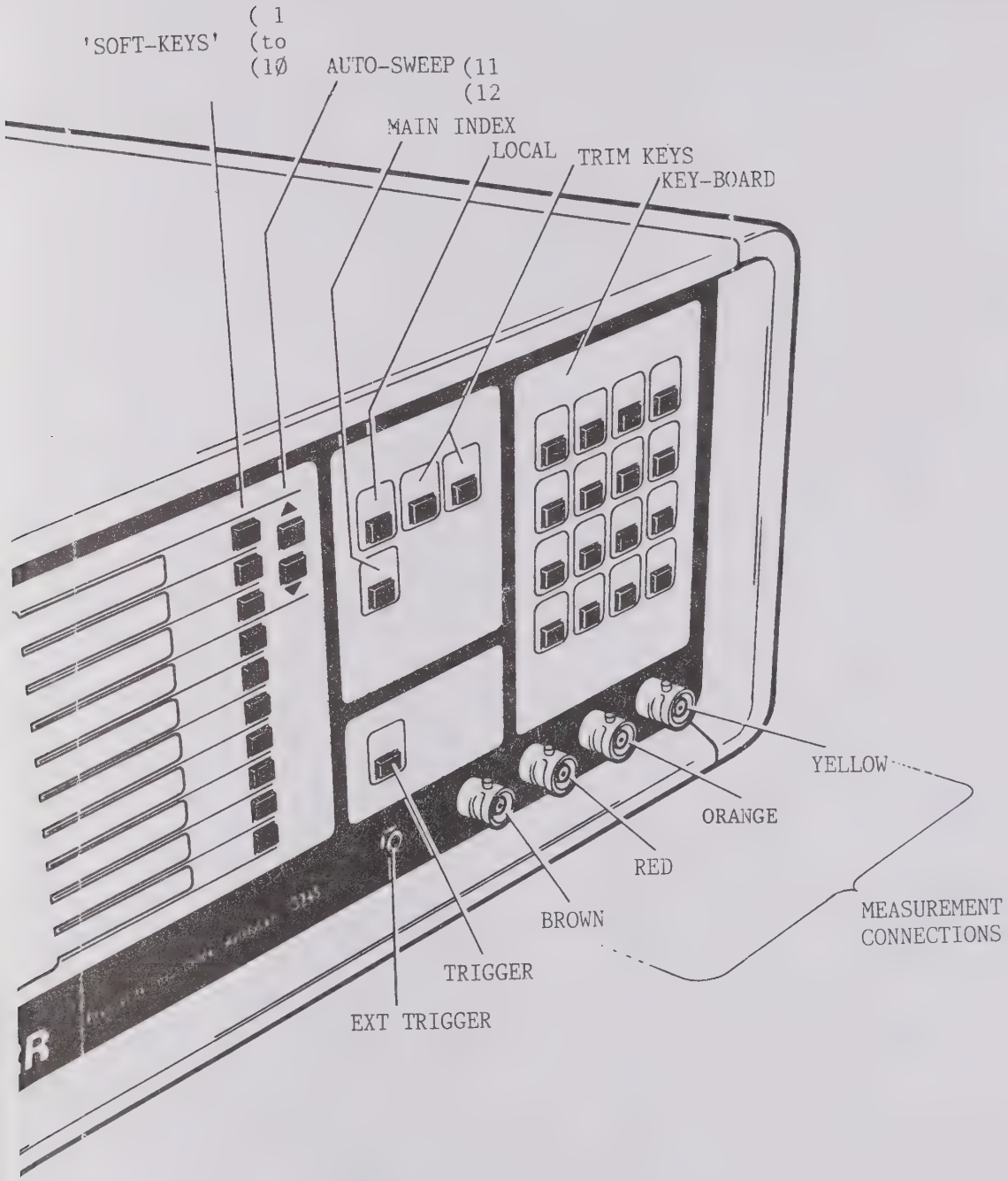


Figure 2 Precision 4-terminal measurement:
the 3245 Analyzer with Kelvin leads



Figur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(1
(to
(1Ø
AUTO-SWEEP
(11
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MAIN INDEX
LOCAL
TRIM KEYS
KEY-BOARD
YELLOW
ORANGE
RED
BROWN
MEASUREMENT
CONNECTIONS
TRIGGER
EXT TRIGGER

MANUAL FOR THE PRECISION INDUCTANCE ANALYZER 3245

2. INTRODUCTION

The 3245 inductance analyzer design is based on precision measurement circuits controlled by a micro-processor. The resulting instrument, with a basic ac measurement accuracy of Ø.1%, yet requiring the minimum of skill to operate, is intended primarily for wound component measurements. It can also deal with measurements of resistance and capacitance.

There are several operating modes for different types of measurement. Pressing MAIN INDEX at any time displays the list of modes against their respective selection keys.

Operating conditions cover wide ranges of ac level, dc bias, frequency and selection criteria (binning and deviation) whilst measurements and displays can be for series, parallel or polar interpretations.

Trimming adjustment and ranging are achieved automatically. Trim (O/C and S/C) and MAIN INDEX functions are selected from a group of four buttons; the fourth permits local override of remote operation.

The standard facilities include limits for go/no go testing, deviation, binning (1Ø classes - 8 for passes), repetitive and single shot measurements. Measurement parameters, e.g. drive, bias current, frequency and mode, are indexed on a screen, each alongside a soft-key to control automatic adjustment (settings may also be entered via a numeric key-board).

A component fixture unit (1ØØ5) for rapid connection of components with axial or radial leads is available but normally the analyzer is supplied with two sets of measurement leads:-

a) A pair of Kelvin clip leads (16Ø5) for normal four-terminal measurements.

b) A set of crocodile connector leads (15Ø5) for use with transformers and also for situations where two and three terminal measurements suffice.

The instrument requires ac power.

The portable version, illustrated opposite in figure 2, can be mounted on runners in a standard 19-inch rack after fitting 'ears' to the sides and removing the feet. (There must be runners to take the weight.) This arrangement is suitable for a more permanent installation.

Finally, various plug-in options permit interfacing with other computer controlled equipment and remote control operation is possible.

3. SPECIFICATIONS

3.Ø1. MEASUREMENT FEATURES

3.Ø1.Ø1 MEASURING SYSTEM

The 3245 measuring system and soft-key controls are micro-processor based. All selected functions are retained in non-volatile memory when the instrument is powered-down. Keys can be 'locked out' to prevent accidental or unauthorised modification to measurement conditions. Remote triggering of measurement, by contact closure, is possible. Plug-in options are available for interfacing to external equipment such as controllers, printers etc.

3.Ø1.Ø2 MEASUREMENT DISPLAY

A 175mm CRT displays measured values and other user data. Resolution of displayed results is up to five digits depending on measurement accuracy.

3.Ø1.Ø3 MEASUREMENT PREPARATION - TRIMMING

TRIM S/C and TRIM O/C initiate procedures which automatically compensate for residual series impedance and parallel capacitance in the measuring leads, up to 1.25Ω and 5ØpF maximum. Trim values are retained in non-volatile store.

3.Ø1.Ø4 MEASUREMENT FUNCTIONS

The functions available are:-

L with Q, D or R (Series or parallel equivalent circuit)
C with Q, D or R (Series or parallel equivalent circuit)
Z with /θ, Vac/Iac
Rdc
Lm
TRANSFORMER turns-ratio (measured as a voltage ratio)
TRANSFORMER secondary turns (for user specified primary turns)

For non-transformer functions the following modes are also available:-

DEVIATION - Absolute or % deviation from nominal
LIMITS - Absolute or % limits for GO/NO GO testing
BINNING - Sorts into 1Ø bins, 8 for different values,
1 for MAJOR term rejects, 1 for MINOR term rejects
Sorted results are displayed (with or without a handler)

3.Ø1.Ø5 MEASUREMENT CONDITIONS - ac

Frequency (Hz): A built-in pattern of specific values at

2Ø, 25, 3Ø, 4Ø, 5Ø, 6Ø, 8Ø, 1ØØ, 12Ø, 15Ø, 2ØØ

The pattern repeats each decade up to 6Ø kHz, then frequencies of 75, 1ØØ, 12Ø, 15Ø, 2ØØ and 3ØØkHz complete the set. When a frequency is keyed-in the system automatically selects the nearest value from the built-in range.

3.Ø1.Ø5 MEASUREMENT CONDITIONS - ac - (Continued)

Drive level: The drive mode (current/voltage) changes automatically, depending on the test impedance. The Z function display includes either the voltage developed across the unknown impedance (current drive selected) or the current through the unknown impedance (voltage drive selected).

1mA	- 5ØmA	in	1mA steps)	Zu ≦ 1ØΩ
5ØmA	- 1ØØmA	in	2mA steps)	
1ØmV	- 5ØØmV	in	1ØmV steps)	Zu ≧ 1ØΩ
5ØØmV	- 1.ØV	in	2ØmV steps)	
1V	- 2.5V	in	5ØmV steps)	Zu ≧ 8ØΩ
2.5V	- 5.ØV	in	1ØØmV steps)	Subject to 3V maximum at 3ØØkHz

BIAS (dc): Internal supply has a separate on/off control and uses a rear panel mounted safety link. BIAS is always OFF at power-up.*

1mA	- 5ØmA	in	1mA steps
5ØmA	- 1ØØmA	in	2mA steps
1ØØmA	- 25ØmA	in	5mA steps
25ØmA	- 5ØØmA	in	1ØmA steps
5ØØmA	- 1A	in	2ØmA steps

External option 322Ø is an alternative dc BIAS source. It provides 2ØØmA to 2ØA in steps of 1ØØmA, for use with frequencies up to 2ØkHz. Up to five units may be paralleled with the 3245, replacing the internal BIAS supply.

3.Ø1.Ø6 MEASUREMENT CONDITIONS - dc resistance

The dc drive level depends on the measured value; it is always less than 1ØØmV and 16mA.

3.Ø1.Ø7 MEASUREMENT CONDITIONS - ACCURACIES

Frequency accuracy: ±Ø.Ø1%

Level accuracy - ac

Frequency Range:	O/C Voltage Accuracy		S/C Current Accuracy	
3ØHz - 12ØkHz	±4%	±2mV	±5%	±2ØØµA
2ØHz - 25Hz) 15ØkHz - 2ØØkHz)	±7.5%	±2mV	±8.5%	±2ØØµA
3ØØkHz	±11.5%	±2mV	±12.5%	±2ØØµA

Loading effect: - ac
Maximum change in level occurs at Zu=1ØΩ. For reactive unknown impedances (Q≮25) maximum falls in level are voltage 4% and current 3%.

Current accuracy - dc BIAS: ±2.5%, ±Ø.25mA

* New safety features: see Chapter 8, page F:2.

3.Ø1.Ø8 MEASUREMENT RANGES, ACCURACY and RESOLUTION

Range matching to measured items is automatic unless inhibited by HOLD. If HOLD is selected, a RANGE ERROR message shows when a change of range could produce better measurement accuracy.

Seven ac impedance ranges are available.

Range No.	Impedance Coverage	Maximum Level
1	<1.25Ω	1ØØmA
2	<1ØΩ	1ØØmA
3	>1ØΩ	1V
4	>8ØΩ	5V
5	>64ØΩ	5V
6	>5k12Ω	5V
7	>41kΩ	5V

Notes: Maximum level at 3ØØkHz is 3V.
Range 7 is unavailable above 6ØkHz.
At <25ØmV range 7 is unavailable; also range 6 is unavailable above 6ØkHz.
At >25mA range 1 is unavailable.

Two dc resistance ranges are available.

Range	Resistance coverage	Maximum Level
Normal	>2Ω	1ØØmV or 2mA
Low	<2Ω	1ØØmV or 16mA

On all ranges, accuracy and resolution depend on the specific test conditions and impedance being measured. The basic ac measurement accuracy is ±Ø.1%. This applies, assuming proper trim, to any component with an impedance between Ø.16 and 33Øk in the frequency range 1ØØHz to 5kHz, normal speed, for levels of 25ØmV to 5V or 1ØØmA, no dc BIAS applied. Figures 3 - 5 show inductance accuracies with other drive conditions. Accuracy changes obtained from these charts apply equally to Q and D measurements. Except where stated, the standard conditions above apply to the following accuracy ranges. All resolution figures improve by 2:1 with SLOW selected.

Inductance: Resolution: Ø.5nH at 1ØkHz and above

Accuracy:	Frequency	Max.Value	Min.Value
±0.1%*	1ØØHz	5ØØH	25ØµH
	1kHz	5ØH	25µH
	1ØkHz	5H	4µH
±Ø.5%*	1ØØHz	4ØØØH	25µH
	1kHz	4ØØH	2.5µH
	1ØkHz	4ØH	Ø.6µH
	4ØkHz	1.8H	Ø.6µH
±1%*	1ØkHz	6ØH	Ø.3µH
	5ØkHz	2.5H	Ø.6µH
	1ØØkHz	4ØmH	Ø.9µH

Q-Factor: Maximum display with ±5% resolution: Q = 13ØØ
Accuracy: ±Ø.1(Q + 1/Q)%

* When Q > 1Ø. If Q < 1Ø, multiply accuracy figures by (1 + 1/Q).

3.Ø1.Ø8 MEASUREMENT RANGES, ACCURACY and RESOLUTION (Continued)

Capacitance:

Resolution: Ø.Ø1pF at 1ØkHz

Accuracy:	Frequency	Max.Value	Min.Value
±Ø.1%*	1ØØHz	1ØmF	5nF
	1kHz	1mF	5ØØpF
	1ØkHz	5ØµF	5ØpF

Dissipation Factor:

Resolution: Ø.ØØØ2
Accuracy: $Ø.ØØ1(1+D^2)$

Impedance/ac Resistance:

Resistance: Ø.Ø2mΩ

Accuracy:	Frequency	Range
±Ø.1%**	1ØØHz - 5kHz	Ø.16Ω to 33ØkΩ
	5kHz - 1ØkHz	Ø.33Ω to 33ØkΩ

Phase Angle:

Resolution: Ø.1°
Accuracy: ±Ø.2°

Turns Ratio (as a voltage ratio)

Accuracy: ±Ø.1% over range 1:1ØØ to 1ØØ:1

dc Resistance:

Resolution: Ø.2mΩ
Accuracy: ±Ø.5% in range Ø.2Ω to 5kΩ

3.Ø1.Ø9 MEASUREMENT REPETITION SELECTION

Measurement sequence is free-running or single shot; selection is by soft-keys, see figure 12. Single shot measurements are triggered by front panel button or remote contact closure.

Measurement speed: The reading rate affects the accuracy and resolution; choices, at 1 kHz ac drive, are:-

Normal	3/sec	approximately
Fast speed (reduced accuracy)	8/sec	
Slow speed (improved resolution)	1/sec	

At the fast speed setting, line frequency rejection worsens and basic accuracy worsens by 5:1, subject to adequate supply screening.

At the Slow speed setting, line frequency rejection is enhanced and all resolutions improve by 2:1.

With Normal or Fast settings, speed slows progressively below 3ØØHz to about 1.6/second at 2ØHz.

* When D < Ø.1. If D > Ø.1, multiply accuracy figure by (1 + D).

** When Q < Ø.1 (D > 1Ø). For loss resistance of an inductor, multiply accuracy figure by (1 + Q). For loss resistance of a capacitor, multiply accuracy figure by (1 + 1/D).

3.Ø1.1Ø MEASUREMENT TERMINALS

Four BNC connectors provide 2, 3 and 4 terminal connections. Lead connection diagrams are available on the crt display. As a safety feature, measurement terminals are internally protected against accidental connection of charged capacitors and inductor back emf.

Single-pole Remote Triggering Contacts connect to the 3245 via a 3.5mm jack-socket mounted below the front panel trigger button, see figure 1. Contact current is mA only; neither side is grounded.

An external link - suitable for 1A current - is necessary for use of the internal BIAS supply. Terminals are on the rear panel, see figure 32.

3.Ø2 ANCILLARY FEATURES

3.Ø2.Ø1 NON-VOLATILE MEMORY

The non-volatile memory is powered by a lithium battery with a service life exceeding 1Ø years. The parameters retained are:-

TRIM
MAIN INDEX mode selection
FREQUENCY
DRIVE (ac, dc)
BIAS level (But on re-powering, BIAS will be OFF)
MAJOR TERM)Measurement
MINOR TERM)parameters
AUTO-RANGE or RANGE-HOLD
Selected Range (In RANGE-HOLD)
SINGLE-SHOT/REPETITIVE
SPEED
LIMITS
BIN SET DATA
BIN COUNT DATA
Parity checking at power-up ensures that non-volatile data is valid

3.Ø2.Ø2 ACCESSORIES

1. Type 16Ø5 - Four-terminal leads terminated with Kelvin clips.

2. Type 15Ø5 - Four-terminal leads terminated with Crocodile clips. These may also be used for connection to 3- or 2-terminal networks and transformers.

3. Type 1ØØ5 - Component fixture unit, suitable for both radial and axial components.

4. Rack Mounting Kit - 2 mounting brackets and screws. Part number 25539

Standard shipment: The 3245 analyzer plus accessories 16Ø5 and 15Ø5.

3.Ø2.Ø3 OPTIONS (See also Appendices)

Various options for interconnection to other equipments are available. All are accessed on the back panel.

1. 322Ø dc Extension (2ØAmp). Comprises a separate unit of the same physical dimensions as the 3245. Up to five units may be stacked as a BIAS source (currents to 1ØØAmp) replacing the internal 1Amp dc source. Operationally the analyzer and soft-keys control the units. All 3245 measurement functions are available up to 2ØkHz.*

2. RS232C interface - provides:-

   Serial output of measurement data conforming to RS232C format to, for example, a printer.

3. GPIB interface - is implemented to the IEEE standard 488 (198Ø) (basic Talker and Listener) - and provides either:-

   (i) Full remote control of all functions including data entry and read-out, or

   (ii) Automatic output of measurement data to, for example, a printer.

4. Analogue output - provides one or two analogue outputs corresponding to selected measurement functions.*

5. Binning Handler Interface - provides connections to automatic component handlers.

3.Ø2.Ø4 TEMPERATURE RANGE

Storage	-4Ø°C to +7Ø°C	-4Ø°F to +158°F
Operating	Ø°C to +4Ø°C	+32°F to +1Ø4°F
Full Accuracy	+1Ø°C to +3Ø°C	+5Ø°F to +86°F

3.Ø2.Ø5 SUPPLY VOLTAGE

115V ±1Ø% or 23ØV ±1Ø% ac only (Must be correctly selected)

Power consumption 7ØVA nominal. The instrument may be converted for 5ØHz or 6ØHz operation by means of an internal wire link. (If this is not set correctly the instrument will continue to operate but not to full specified accuracy.)

3.Ø2.Ø6 DIMENSIONS

Width:	443mm	17.5in
Height (including feet):	195mm	7.5in
Depth (overall):	47Ømm	18.5in
Weight:	16kg	35lbs

3.Ø2.Ø7 DISCLAIMER

In step with rapidly developing technology the Company is continually improving its products and therefore reserves the right at any time to alter specifications or designs without prior notice.

* New safety features: see Chapter 8, page F:2.

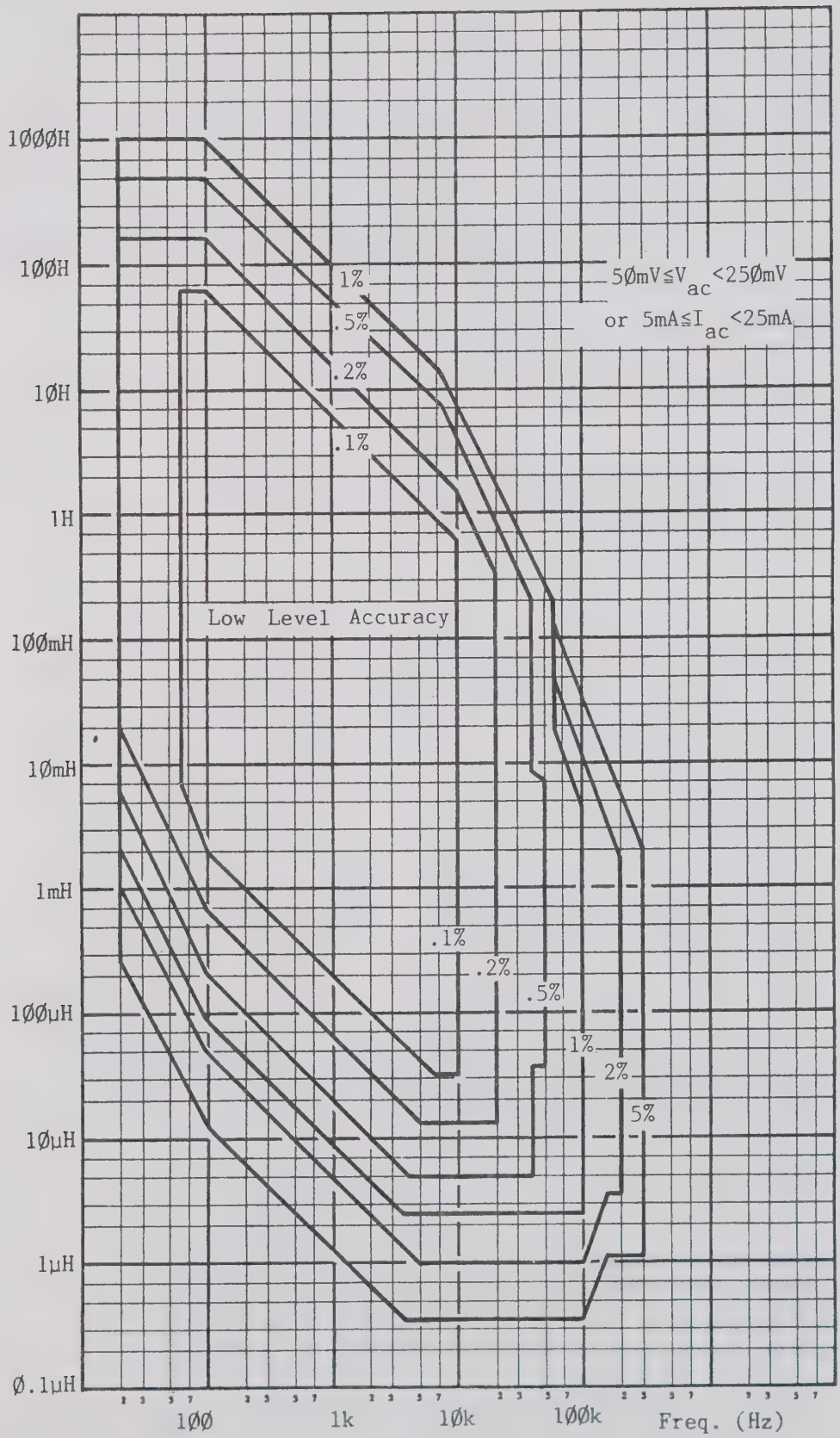

Figure 3 Accuracy Chart - low level drive, no BIAS

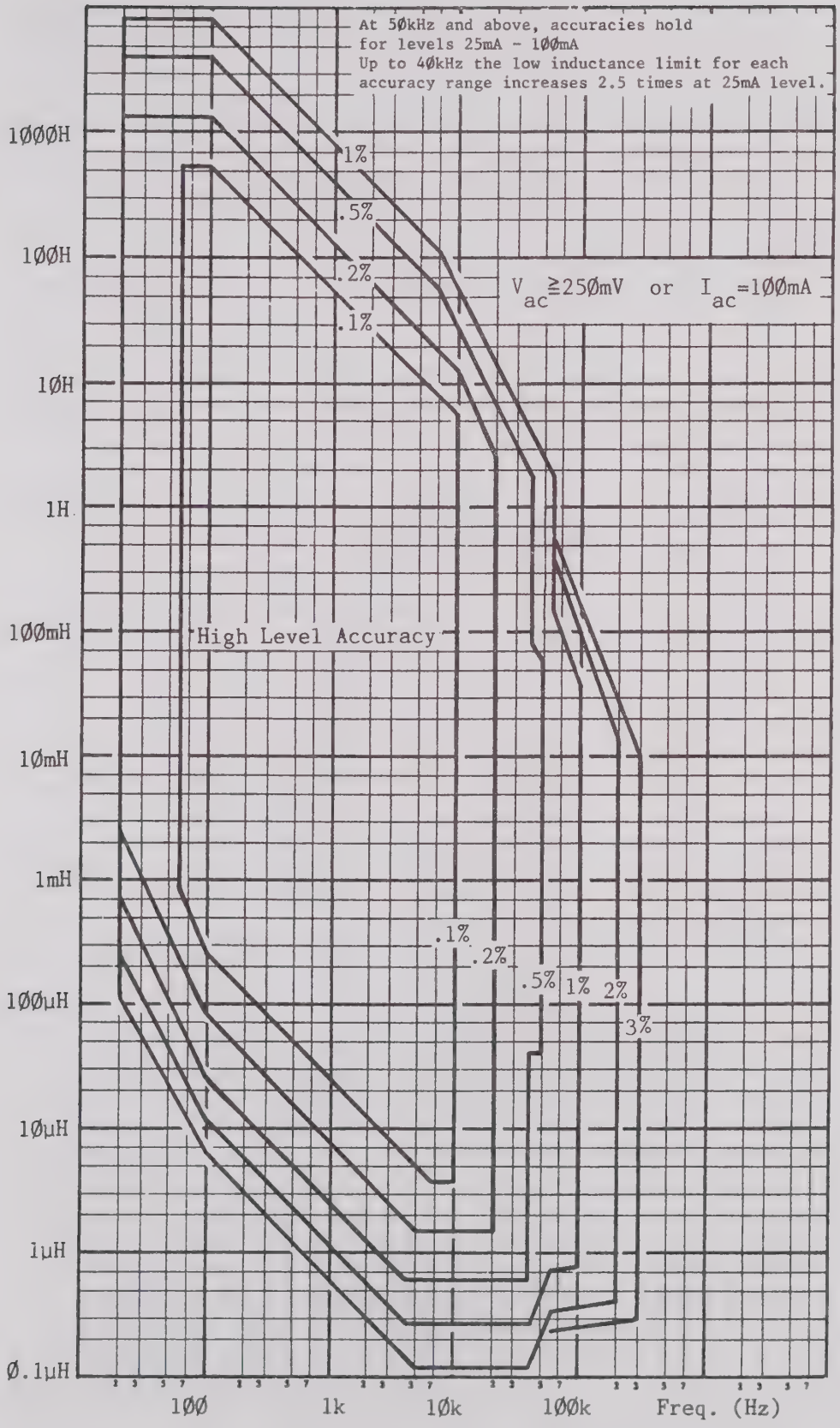

Figure 4 Accuracy Chart - high level drive, no BIAS

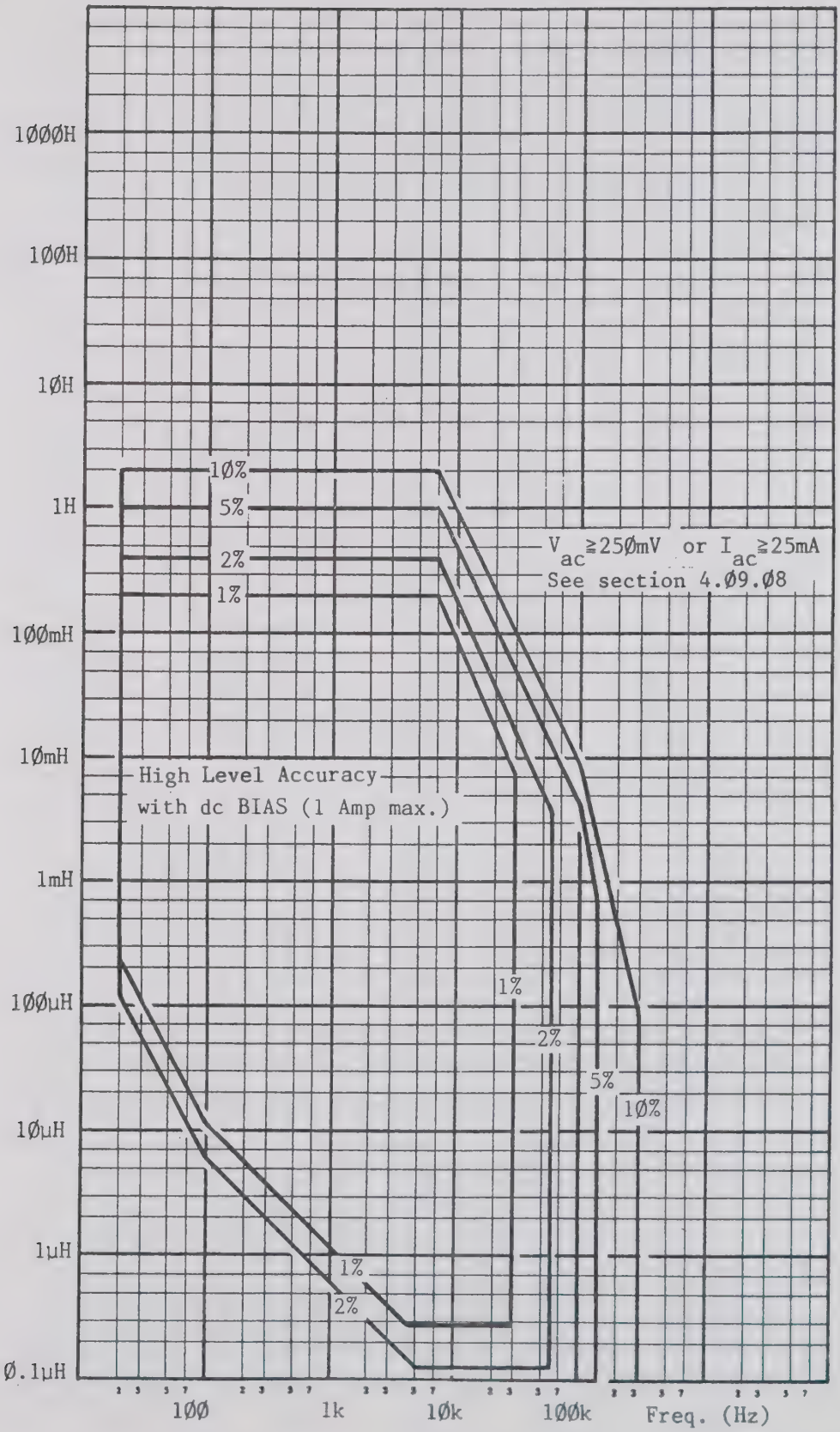

Figure 5 Accuracy Chart - high level drive, with 1Amp dc BIAS

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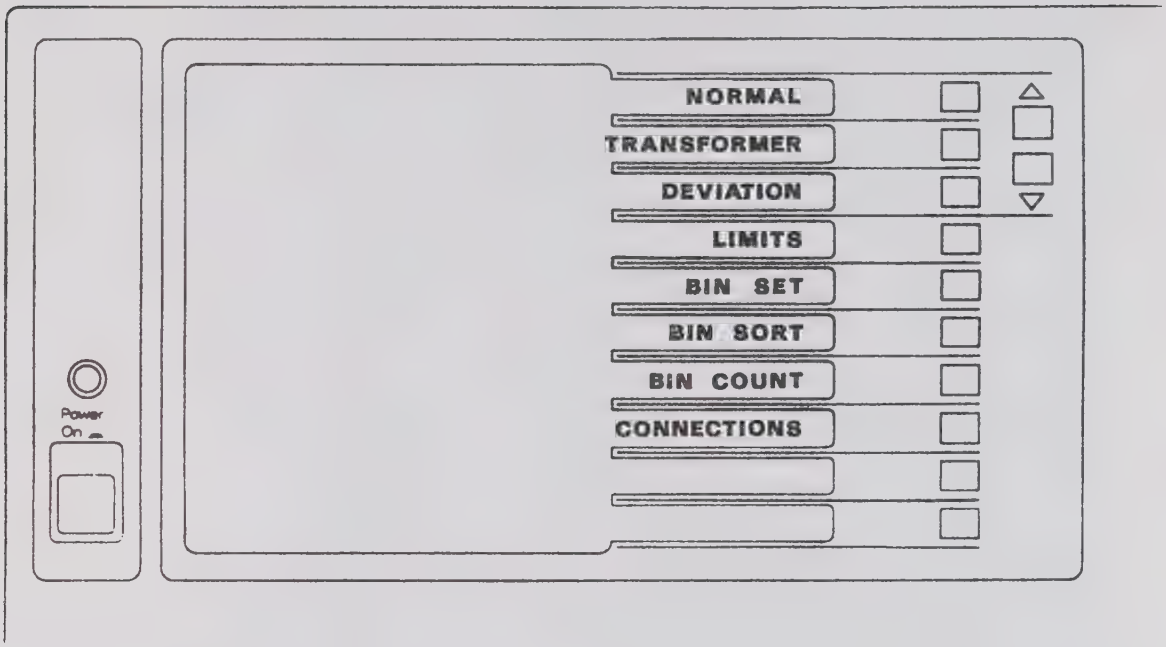


Figure 6 MAIN INDEX

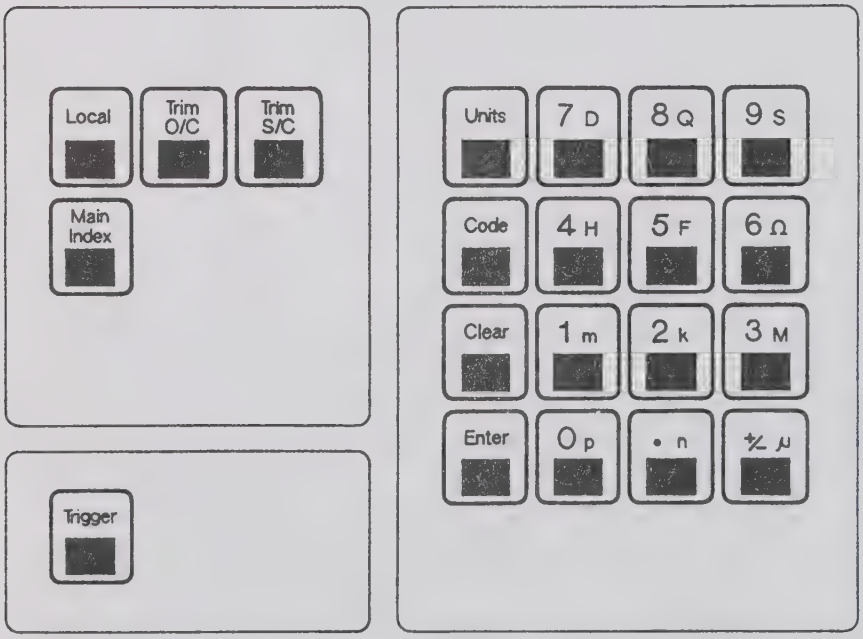


Figure 7 Main Function Keys and Key-Board

4. OPERATION

4.Ø1 BASIC INFORMATION

4.Ø1.Ø1 POWER SUPPLY - Leads and Adjustments - and INITIAL USE

The power lead shipped with the analyzer has a moulded supply plug. Users fitting an alternative plug should note the lead colour code:-

LINE → BROWN; NEUTRAL → BLUE; GROUND → GREEN/YELLOW

For operator safety the GREEN/YELLOW lead must be grounded.

Before first use of the 3245 Analyzer, ensure that the supply frequency, voltage settings and fuse rating are correct, then connect the supply and switch on. The instrument will operate with the power frequency incorrectly selected but for full specified accuracy correct setting is essential.

Operation is monitored on and prompted by screen displays e.g.figures 6, 13 etc. The display brightness control is on the back panel (figure 32).

The TRIM state, as last set in the factory, will normally be applied at power-up. Since the supplied connections may not be those used for the pre-despatch test, connect the operating leads and retrim. (When connecting the supplied test leads, match coloured sleeves to coloured sockets. Alternative leads should be constructed as described in section 4.Ø9.Ø2.)

The analyzer may be rack mounted on suitable runners; a kit of brackets and screws is available (see 3.Ø2.Ø2). Adequate ventilation is required but the top and bottom covers must stay fitted during use.

4.Ø1.Ø2 BASIC FEATURES

Display at power-up is normally as at last usage except that the BIAS will be turned OFF and, when SINGLE SHOT was operative, there will be no measurement result. If the previous 'set-up' has been lost - arising from corruption of non-volatile RAM - then a warning is displayed; see section 7.Ø2.Ø2. At this state TRIM, then key-in new data.

1. Press MAIN INDEX to display the operating modes. Any may be selected by pressing the button adjacent to its displayed legend. The key-board, figure 7, is for entry of data not otherwise selected.

2. Maximum ac signal level varies with selected impedance range:-

Z < 1Ø ohms;	1ØØmA rms maximum
1Ø < Z < 8Ø ohms;	1V rms maximum
Z > 8Ø ohms;	5V rms maximum (3V at 3ØØkHz)

The displayed MINOR TERM on the Z function can be the drive dependent parameter - unknown voltage (current drive selected) or unknown current (voltage drive selected).

3. A suitable test item must be connected before BIAS can be enabled. To avoid risk of shock from back emf, always turn OFF the BIAS before disconnection. The 3245 is internally protected against back emfs.

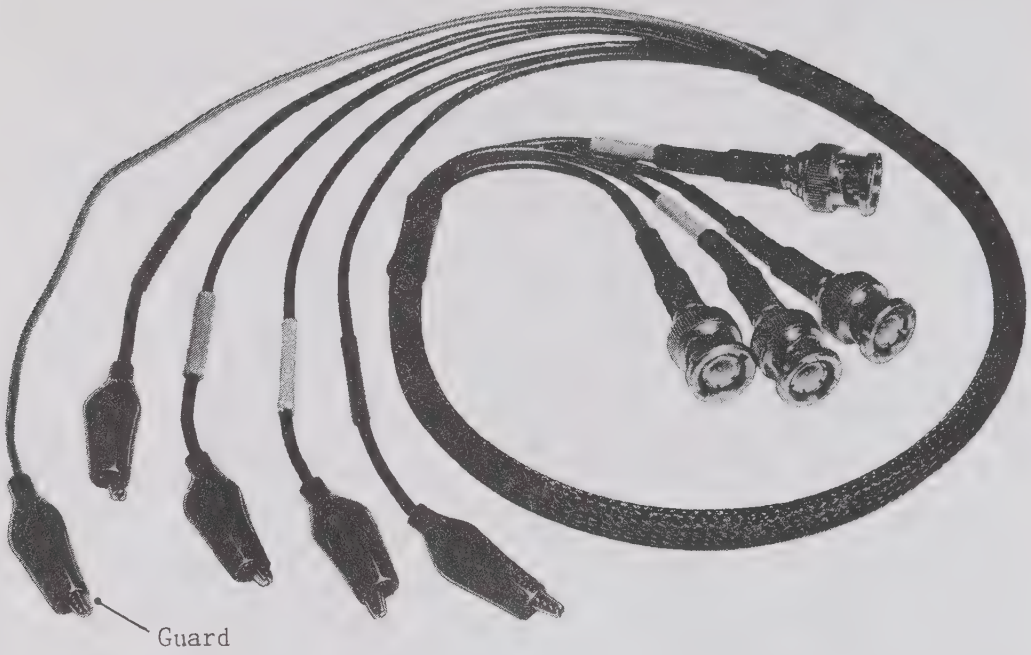


Figure 8 Crocodile clip leads (15Ø5)

Figure 9 Component Fixture Unit (1ØØ5)

4.Ø1.Ø2 BASIC FEATURES (Continued)

4. Link the BIAS terminals on the rear panel (figure 32) if measurements using the internal BIAS current are intended. Before measuring inductors which may be damaged by dc BIAS e.g. tape heads, microphone inserts etc., remove the link as a safety precaution.

5. A fixed low level dc of <1ØØmV, from a source impedance of approximately 55 ohms (NORMAL range) or 7 ohms (LOW range), is used for Rdc measurements. There is no MINOR TERM. Selecting Rdc extinguishes the frequency and BIAS displays and turns BIAS OFF.

6. The analyzer continuously seeks the appropriate working range when in AUTO mode. The HOLD state permits user selection of any range by code via the key-board; see section 7.Ø2 for codes and ranges.

7. Alternative measurement speeds can be selected - NORMal, FAST or SLOW - by pressing the adjacent key. All speeds slow progressively for frequencies below 3ØØHz.

   NORMal speed makes approximately three readings per second and provides full measurement accuracy.

   FAST speed makes approximately eight readings per second, suited to initial settings of adjustable components. Accuracy and resolution are reduced.

   SLOW speed makes approximately one reading per second and results in the highest resolution. This speed is suitable for situations where test components are susceptible to power supply pick-up.

8. Key-board data entries are echoed on the bottom (data) line of the screen.

9. Messages and warnings appear as appropriate at the upper and lower levels of the screen. Do not ignore them.

Comparative and selective measurements can be made by the analyzer (DEVIATION, LIMITS and BINNING); these are particularly useful in production work, especially when used with the component fixture accessory.

4.Ø1.Ø3 CONNECTIONS

The available types of connection between the analyzer and test item are:-

Kelvin clip leads (figure 1Ø, 16Ø5) for 4-terminal measurements.
Crocodile clip leads (figure 8, 15Ø5) provide connections for 2- and 3-terminal measurements and transformer measurements.
Component fixture accessory (figure 9, 1ØØ5); for 4-terminal measurements.

The standard kit for shipment includes the first two (15Ø5 and 16Ø5); the fixture (1ØØ5) is available to order.

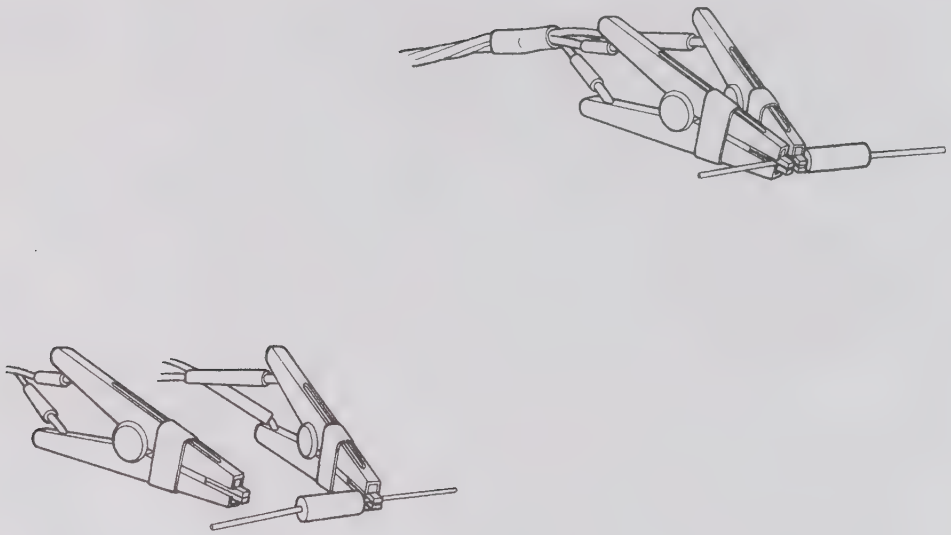


Figure 1Ø KELVIN clip leads (16Ø5) arranged for O/C and S/C TRIM

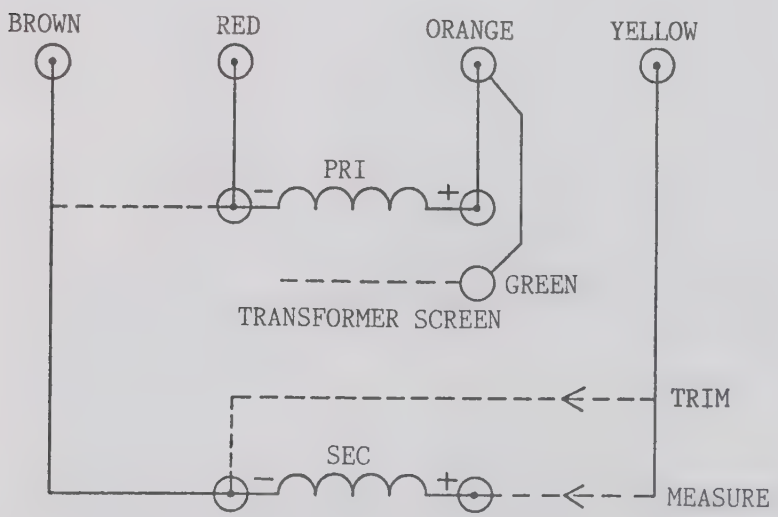


Figure 11 Component and lead arrangement for MUTUAL INDUCTANCE trim and measurement

(Preferably connect the GREEN clip-lead to the transformer screen or frame.) Note the indicated polarity (+) of the windings; non-compliance with this will result in a negative TURNS RATIO display.

4.Ø1.Ø4 TRIMMING

The purpose of trimming is to eliminate the effects of stray capacitance or series impedance in the connecting leads or fixture. It must be done each time that lead sets or component fixtures are changed.

At power-up the previously used trim values are immediately re-established from non-volatile memory. If the re-instated trim values will not be applicable or if maximum accuracy is required, automatic re-trim (S/C for low impedance measurements or O/C for high) can be obtained by pressing the appropriate TRIM button and complying with the ensuing prompts.

The connector jaws should be as close as possible for S/C trim and at least 5 cm from each other and anything else for O/C trim. See figures 1Ø and 11 alongside for connection arrangements.

DO NOT connect the Kelvin clips together for S/C TRIM.

All of the settings - trim values and interpolations - will hold for all styles and ranges of measurement except for transformer measurements for which a mutual inductance TRIM is available.

Trimming in preparation for measurements on MUTUAL inductance is controlled by soft-key (TRIM Lm). The leads must be placed as near as practical to the positions they will occupy during measurement (see figure 11 for connection arrangement) because the instrument cannot distinguish coupling between connecting leads from coupling in the device under test. The secondary winding should be short-circuited.

Trimming is done with ac drive of 1V or 1ØØmA. Best measurement results are obtained under these conditions.

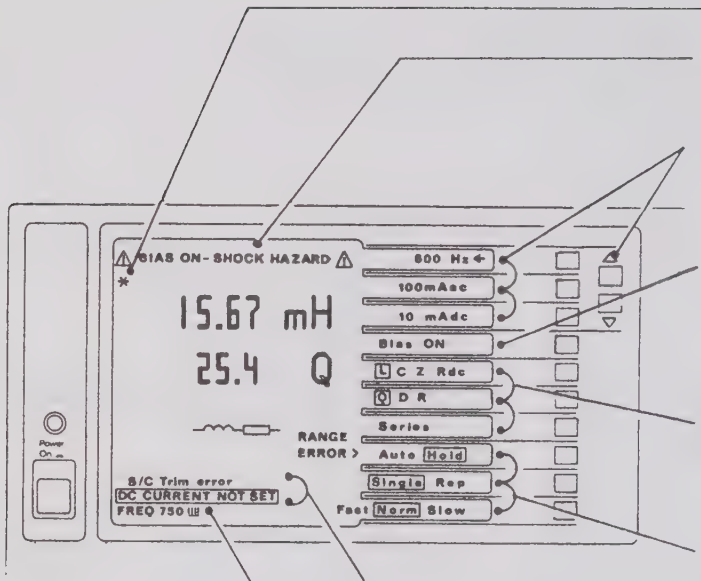
Greatest accuracy at a given measurement frequency is attained when trim operation is initiated with that frequency selected. The 3245 has available 42 set frequencies, any of which can be used during measurement. Trimming is performed for a sub-set of the 42, comprising 14 frequencies selected from an internal table plus the specific one in use when trimming is initiated. The sub-set frequencies have full trimming established. Frequencies excluded from the sub-set have trimming assessments made by interpolation thereby avoiding the need to re-trim when changing frequency. Initiating trim with the measurement frequency in use ensures a non-interpolated correction will be applied at that frequency.

Check trimming in the following manner:-

1) Clamp the test leads onto a heavy gauge conductor as for S/C trim; make a series inductance/resistance measurement. The results should be near zero.

2) Position the test leads for O/C trim, then make a capacitance measurement in parallel configuration. The results should be near zero for capacitance and OVER RANGE for resistance (implying a result close to infinity).

When measuring low inductive impedances or low capacitances very stable lead arrangements are essential.



WARNING line.

* = Measurement in progress.

SIGNAL CONDITIONS - arrow shows parameter to be updated, selected by adjacent soft-key. Use the keys marked with triangles to set values, otherwise enter the data on the key-board.

BIAS cannot be turned ON until test item is connected. Turn OFF BIAS before disconnecting test item.

Select MAJOR (upper) and MINOR (lower) measurement terms and series/parallel equivalent circuit by pressing adjacent keys.

Select MEASUREMENT MODE by pressing adjacent key.

MESSAGE LINES (1 or 2)

DATA LINE for key-board entries

Settings shown here are for NORMAL operation.

Figure 12 Composite display, NORMAL, series L, R measurement

4.Ø2 BASIC MEASUREMENT PROCEDURE

Measurements start with the MAIN INDEX display, see figure 6. Formats of other displays are shown in figure 12 (which is a specially prepared composite illustration). Operator actions for all measurement procedures of the 3245 are broadly similar. Detailed below are the actions for measuring an isolated component - typical model - series L,R. Figure 1 has the controls annotated.

a) Plug into the analyzer the appropriate set of leads; match colours
b) Switch on power to the 3245 analyzer
c) Trim the instrument if necessary - section 4.Ø1.Ø4
d) Connect the test item; the guard lead to frame or screen
e) Press MAIN INDEX BUTTON (16); display like fig. 6
f) Press the NORMAL button (1); display like fig. 12
g) Press the frequency button (1); arrow points to frequency
h) Press either 'Δ' button (11) to increment the parameter
or '∇' button (12) to decrement it (see note 3)
i) Repeat (h) to scan for a suitable frequency
j) Press the MAJOR TERM button (5); select function e.g. 'L'
k) Using the AUTO/HOLD button (8) select AUTO
l) Using the SINGLE/REP button (9) select REP
m) Press the ac drive button (2)
n) Repeat (h) to scan for a suitable drive level
o) BIAS: if dc bias is not required skip to (p)
oa) The BIAS should be OFF. ON would be a fault state
ob) Select BIAS LEVEL button (3)
oc) Repeat (h) to obtain the required BIAS level
p) Press the MINOR TERM button (6) to step to required item
q) Using configuration button (7) select form required
r) Press the SPEED button (1Ø) to select measuring rate
s) If BIAS is required ensure link is fitted before switching the BIAS ON with (4)
t) Read the measurement from the screen
u) If BIAS is ON, switch it OFF with (4)
v) Disconnect the test item
w) Similar tests may be made by repeating from (c, d or g)
x) The analyzer may now be turned OFF.

Notes:

1) Single-shot option at (1) requires TRIGGER after (s)

2) The instrument indicates measuring is in progress by displaying an asterisk "*" in the top left-hand corner of the screen. In single-shot mode the result is blanked until the process is complete. In repetitive mode the previous result remains displayed until the asterisk "*" extinguishes.

3) Alternatively measurement conditions may be entered directly using the key-board. See section 4.Ø9.11.

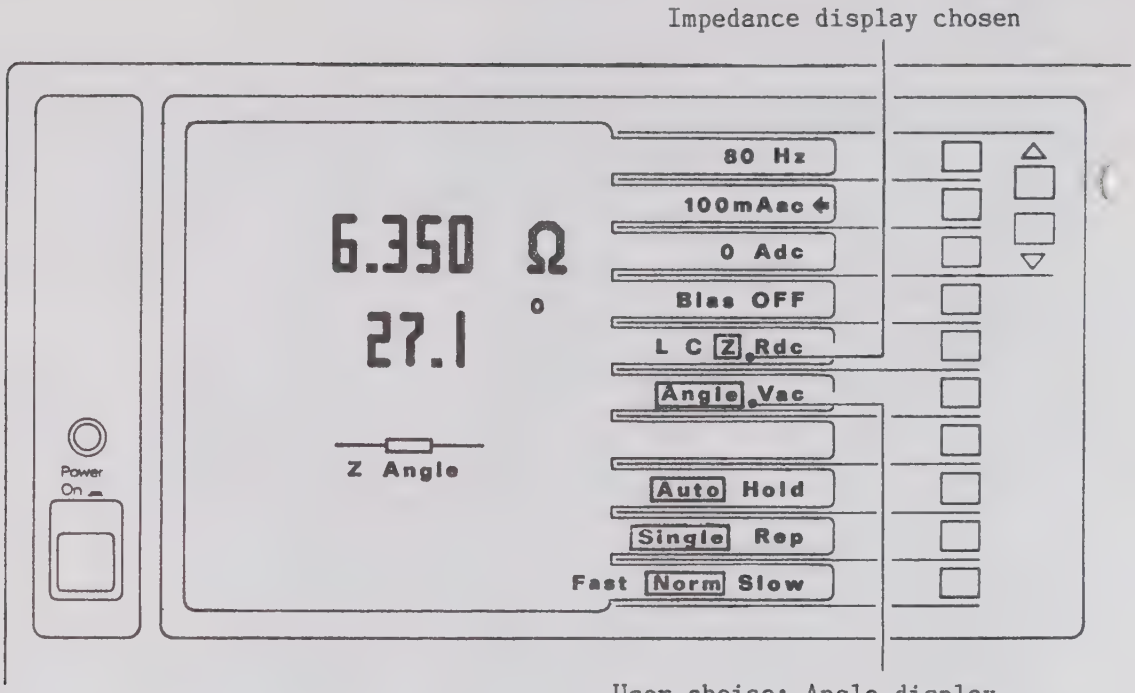


Figure 13 NORMAL, Z, angle

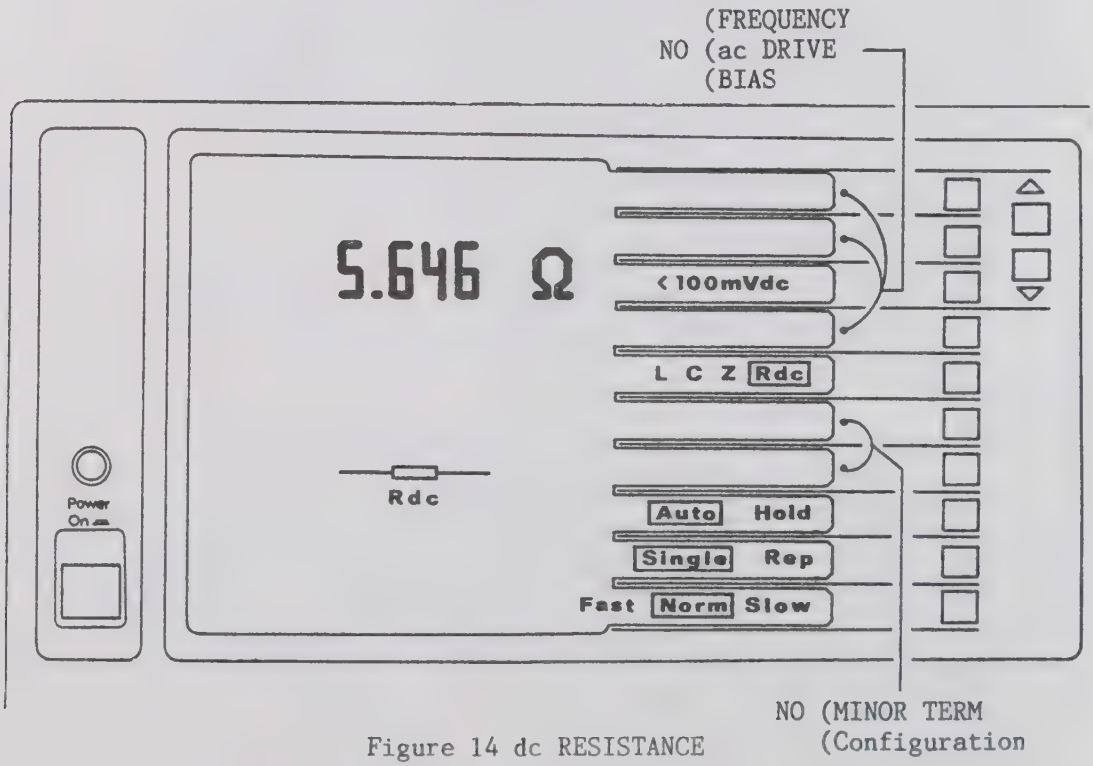


Figure 14 dc RESISTANCE

4.Ø2 BASIC MEASUREMENT PROCEDURE (Continued)

The display shown in figure 13 is typical of Z/θ presentations; note the boxed Z and ANGLE together with the single element configuration. The angle value shows the impedance to be highly resistive; the polarity (implied +ve) indicates that the impedance is inductive at the applied frequency (8ØHz).

As an alternative to ANGLE two other Z displays are available. The selection is shown in the box next to ANGLE. When current drive is applied then Vac, the voltage developed across the unknown, can be displayed. When voltage drive is used then Iac, the current through the unknown, can be displayed.

The 3245 has two ranges for measurements of dc resistance e.g. of the intrinsic resistance of coils. When in the NORMAL mode select the MAJOR TERM as Rdc. The frequency, ac drive level and BIAS soft-key legends extinguish together with those for MINOR TERM and configuration. The dc drive level is automatically limited to a maximum of 1ØØmV or 16mA. Figure 14 depicts the screen display for a resistance measurement.

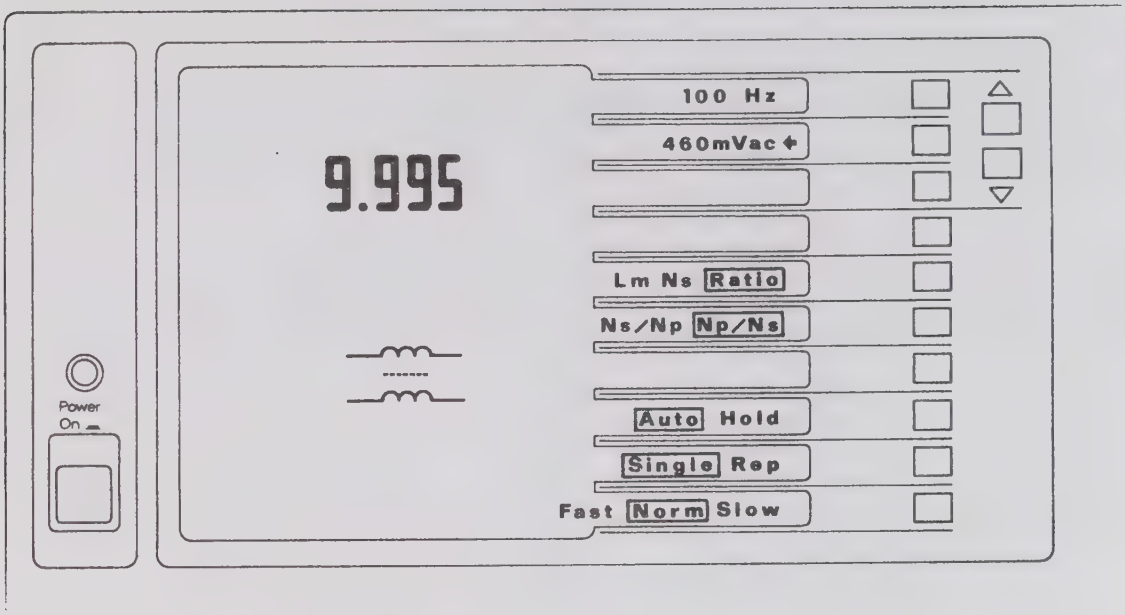


Figure 15 Np/Ns Ratio

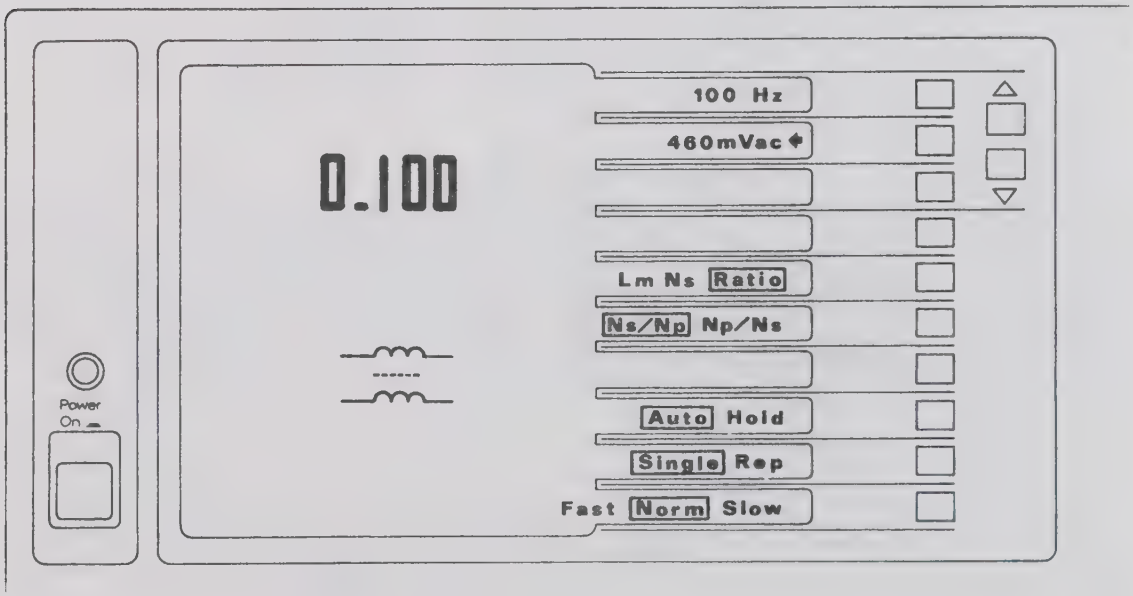


Figure 16 Ns/Np Ratio

4.Ø3 TRANSFORMER MODE

Use crocodile clip leads for transformer winding ratio measurements. RATIOs can be displayed as Np/Ns or Ns/Np. When maximum resolution is required choose the display which is greater than unity. The value displayed is the ratio of measured voltages, hence non-integer results are likely. Trimming (TRIM Lm) is not necessary for RATIO measurements.

For measurement purposes the PRIMARY is the winding connected to the RED and ORANGE sockets, see figure 11.

The connections to the test item for figure 16 were identical to those for figure 15, only the display requirement was changed. Note the result is of only three figures resolution.

If a negative reading occurs when measuring ratio it implies a reverse connected winding; see figure 11 for winding sense convention.

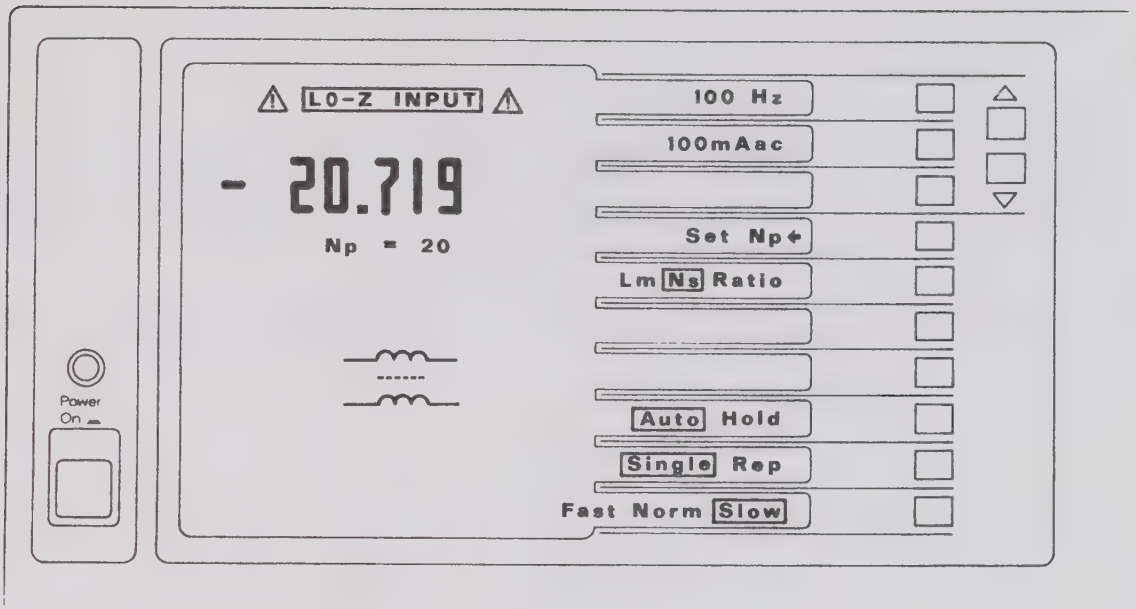


Figure 17 SET Np (Primary turns)

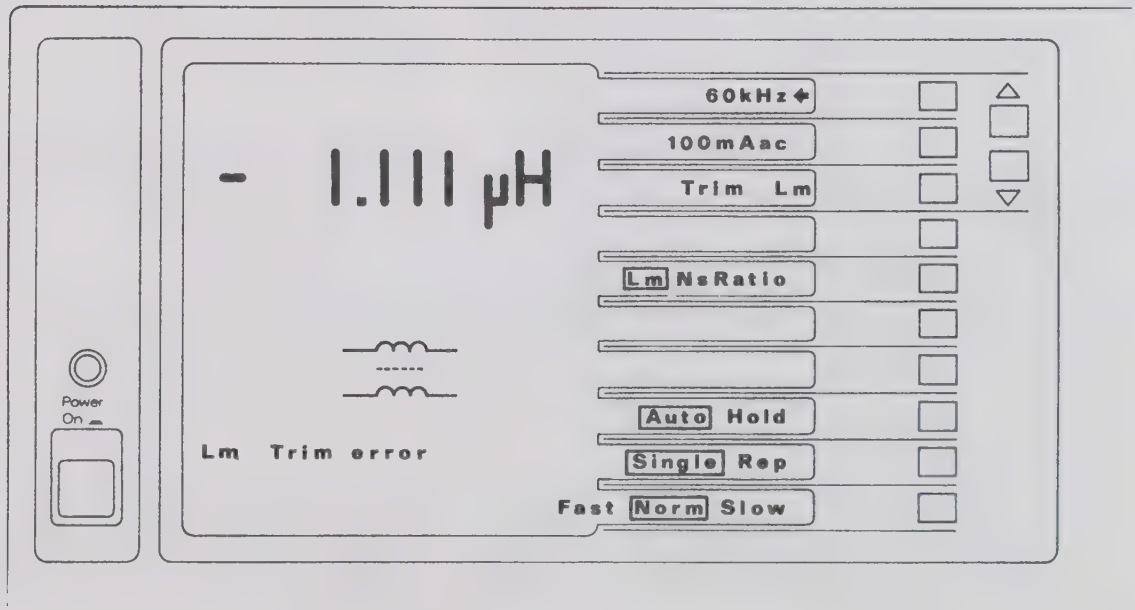


Figure 18 MUTUAL INDUCTANCE

4.Ø3 TRANSFORMERS (Continued)

A SECONDARY turns (Ns) measurement is shown in figure 17. The PRIMARY turns (Np=2Ø, arrowed SET Np) are set via key-board.

The negative reading for SECONDARY turns shows that the measurement connections to the two windings are not in accordance with figure 11 (note the polarity indications).

The upper warning (LO-Z INPUT) means that the measured PRIMARY impedance is particularly low (<5 ohms reactive in this case). Transformer measurements are made under 2-terminal operation so the effects of connection leads cannot be removed. See section 4.Ø9.Ø7 for critical aspects of transformer measurements.

A MUTUAL INDUCTANCE display is shown in figure 18. When Lm is selected the TRIM Lm option appears on screen. Lead positioning during performance of this trim requires extra care; see section 4.Ø1.Ø4.

The negative result in figure 18 arises from one of two possibilities. Either the frequency is above resonance, or a winding connection is reversed. Another measurement at a lower frequency is needed for resolution.

PRIMARY inductance can be measured as a two-terminal operation when using the analyzer on any of the above transformer measurements; simply remove the analyzer connections to the SECONDARY then select NORMAL mode and INDUCTANCE measurement.

A negative reading when measuring PRIMARY inductance indicates that the frequency used is above resonance, consequently the test item is effectively capacitive.

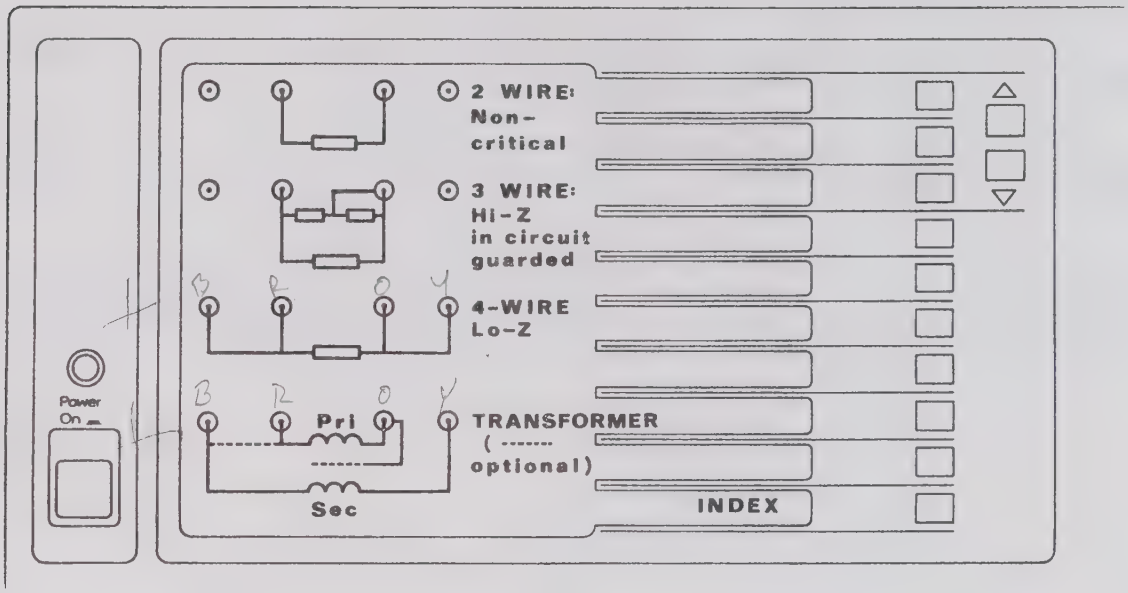


Figure 19 CONNECTIONS

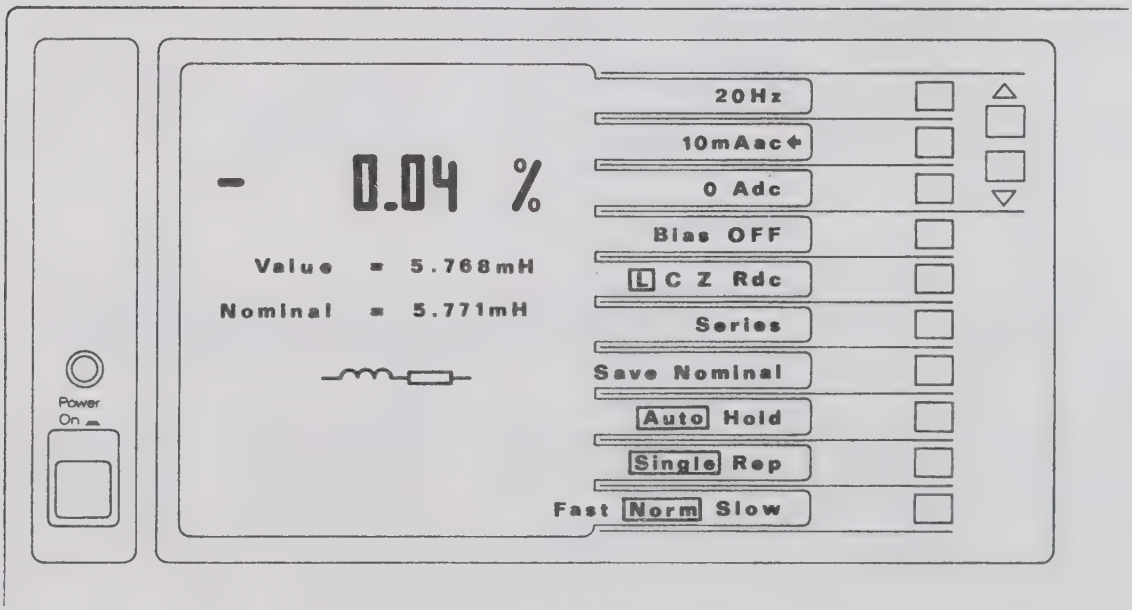


Figure 2Ø DEVIATION

4.Ø3 TRANSFORMERS (Continued)

Connections for transformer measurements are shown in figure 11 but for immediate access the CONNECTIONS display (figure 19), which illustrates the various arrangements, is available from the MAIN INDEX. The four rings represent, from left to right, the front-panel BNC connectors, BROWN, RED, ORANGE and YELLOW. The bottom arrangement, for TRANSFORMERS, requires the use of the crocodile clip leads. Note the optional connection to the winding screen and particularly the arrangement for inter-connected windings.

The phase interpretation for the windings is that the free (non-common) end of each is of the same phase - marked with a '+' in figure 11.

In the case of auto-transformers, it is preferable to measure them in step-down configuration, connected as follows:-

The YELLOW lead connects to the winding TAP.
RED and ORANGE leads go to the winding OUTER connections.
The BROWN lead connects to the same terminal as the RED lead.

The display in figure 19 provides a direct return to the main index - useful during the course of establishing measurement conditions.

4.Ø4 DEVIATION MODE (Single component behaviour)

The prime purpose of DEVIATION mode is to measure parameter variations of a single component as drive conditions etc. change. Batch sorting of components is done in the LIMITS mode, see section 4.Ø5.

To make DEVIATION measurements first establish the nominal value of the component under reference conditions - frequency, BIAS, drive etc. The result will appear against the VALUE legend on the screen. Pressing the SAVE NOMINAL soft-key will store the measured value and also copy it to the NOMINAL display. Measurements at other test conditions can then be made. Results are presented as percentage differences between the nominal and actual values for the MAJOR TERM. A negative value shows that the test result is low compared to the nominal.

Figure 2Ø illustrates this presentation. Any MAJOR TERM can be assessed in this manner.

A MIS-MATCH message appears if the units used for the test do not match the units of the saved NOMINAL. Omitting to save a freshly established NOMINAL - the first step above - is a common cause. The omission results in use of NOMINAL units saved from some other test.

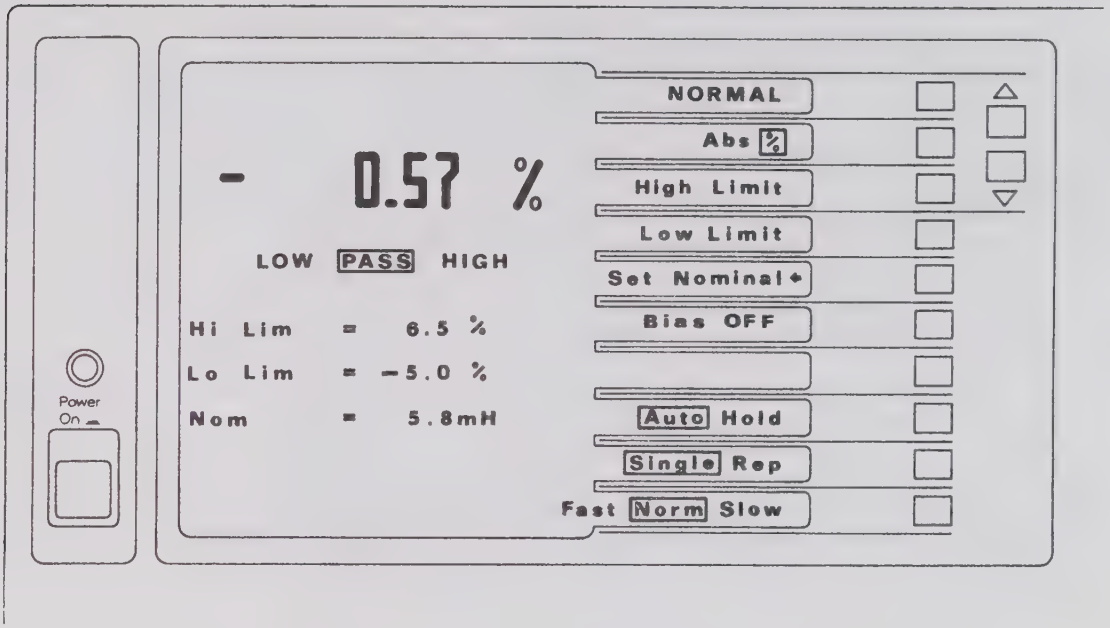


Figure 21 LIMITS % (Percent)

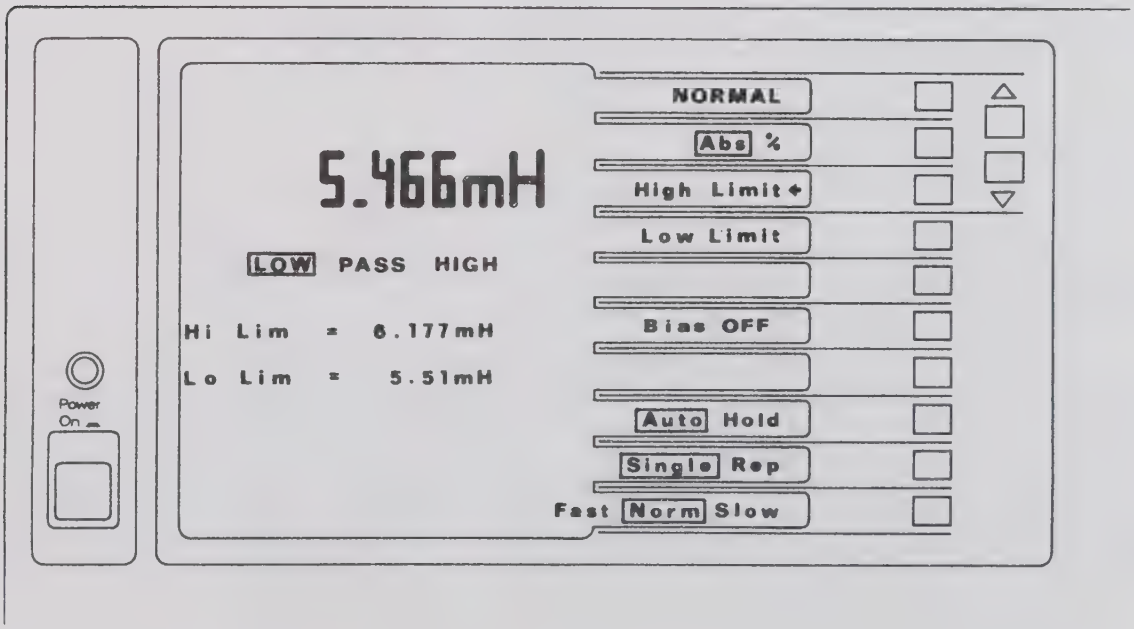


Figure 22 LIMITS Abs (Absolute)

4.Ø5 LIMITS MODE (Batch measurements)

LIMIT measurements are displayed in either of two forms - percentage or absolute. The limits and the nominal value have to be entered via the key-board - there is no facility for saving a measured NOMINAL as DEVIATION mode.

The high limit value must be higher than the low limit value; 'crossed-over' limits are not acceptable in this mode.

A nominal is required only for percentage measurements. Generally symmetric limits will be used, but asymmetric percentage limits can be established. However, the two displays are linked; whichever form is used the values of the limits are maintained.

When absolute limits are set, the analyzer operates without a nominal value. When operation is changed to percentage mode, the display will show the corresponding pair of limits and a mid-way nominal value. If required, specific nominal and/or percentage limits may then be set; they will be reflected in revised absolute values.

The function settings which apply in the LIMITS operation are not directly displayed. They are whatever were last set in the NORMAL mode and can be found by switching to that mode.

Measurement parameters (L, R etc.) and units (mH, ohms etc.) for HIGH, LOW and NOMINAL in the LIMITS mode are compared with those used for the MAJOR and MINOR terms in the NORMAL mode. The message 'MEAS/NOM UNITS MIS-MATCH' is displayed if the settings do not match either.

Figure 21 shows a percentage limit display; the limits are asymmetric. The measurement (PASS) is just a little below the nominal value but well above the lower limit.

Figure 22 illustrates the same settings but with ABS display selected. In this case the measurement value is below the LOW limit.

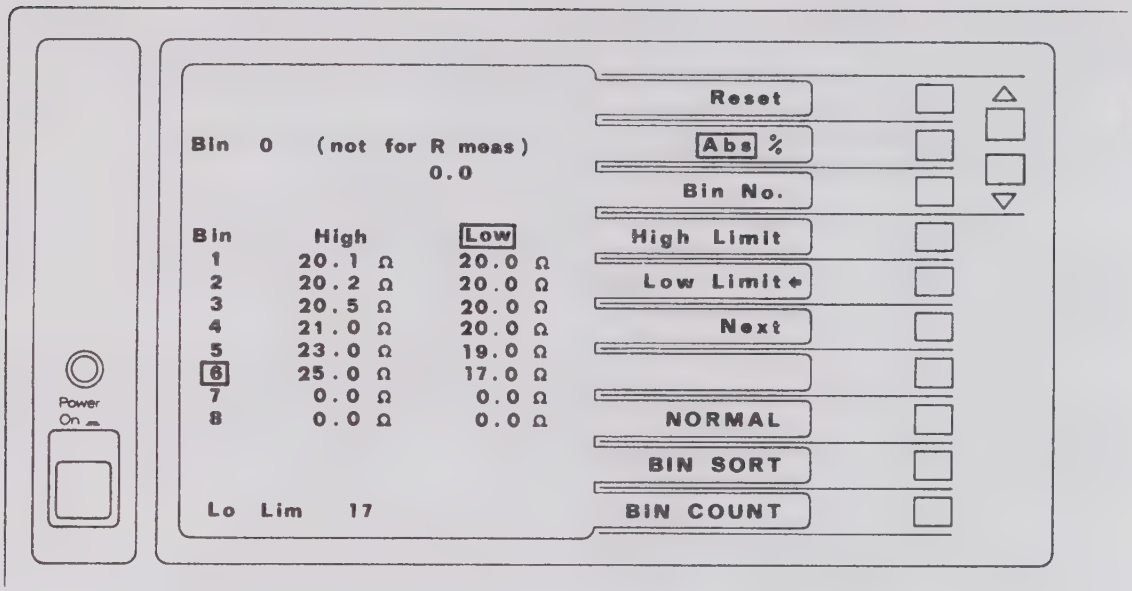


Figure 23 BIN SET Abs (Absolute)

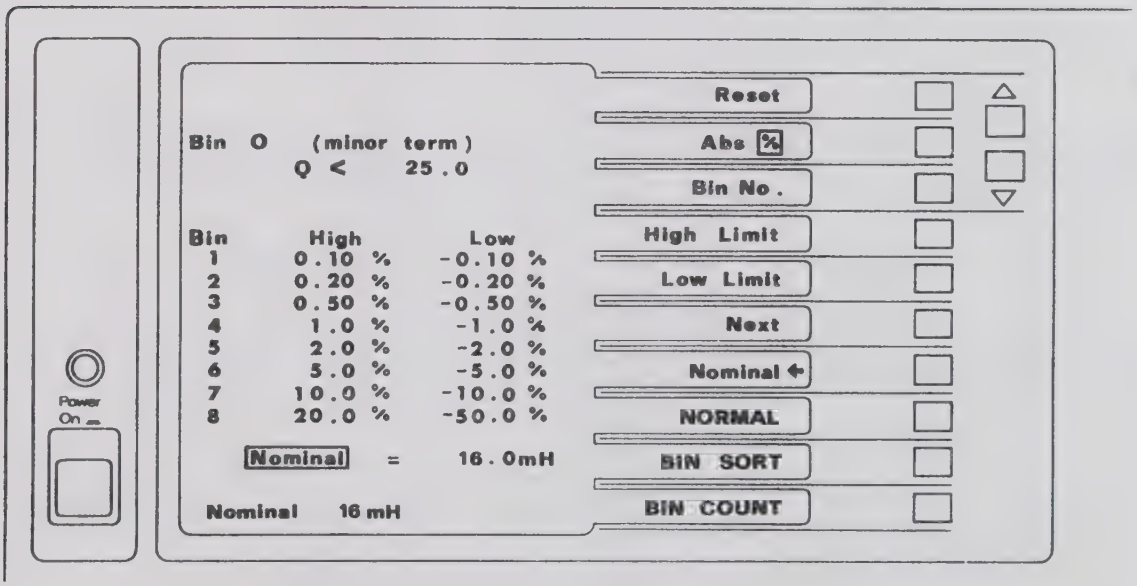


Figure 24 BIN SET % (Percent)

4.Ø6 BIN SET

There are three features concerned with binning - setting the discrimination limits, sorting measured values and displaying the consequent counts. Associated with the second is the electrical interface to binning equipment.

Binning can be done either on an absolute or percentage limits basis. Select BIN SET mode via the MAIN INDEX and choose ABS or % as required; the display should be similar to figure 23 or 24. In ABS mode, units for the limits must be keyed-in (the same for each limit, e.g. all sorting on Ω). In percentage mode, the nominal must have units keyed-in. The parameters and units used for binning must match those in the NORMAL mode (as is the case in the LIMITS mode). Any necessary correction can be made from NOMINAL mode after setting the limits.

Each choice (ABS or %) has its own set of limits although there is one common set of bins. Unlike the LIMITS function, the two sets of binning limits are not linked. Whichever set is chosen, existing limits for that mode can then be reset for a specific bin number, either by explicitly entering zero values in each limit or by pressing the RESET soft-key (button 1). Although RESET puts both the high and low limits to zero (useful for removing old values), it is primarily intended for shutting off unwanted bins after setting other values. If percentage binning is intended, the nominal value should be entered at this point by selecting the NOMINAL soft-key (button 7) then entering the desired value on the key-board.

To select a specific bin, press the BIN NO. soft-key. The actual number may then be chosen via the key-board or either of the AUTO SWEEP keys can be used - they provide a controlled cycling through the bin number range. The latter method of selecting bin numbers is always operational. When a bin number has been selected, press either the HIGH limit or LOW limit soft-key to allow entry of a value via the key-board (units will be required when ABS is used). The current selection remains boxed. Enter the required value and units on the key-board. Another bin may then be selected.

Usually the bins will be dealt with in sequence; selection of the next limit for data entry is achieved by pressing the NEXT soft-key. This steps selection, column by column, row by row. Note that in % mode, symmetrical limits are obtained by default by double use of the NEXT key.

Figure 23 depicts the result of BIN SET actions for ABSolute values - in this case, ohms. Note the asymmetric limits and the partial use of the bin range. The bins with zero limits will not be used.

Figure 24 is for a typical percentage limits case. It shows the nominal data entry and the use of Bin Ø.

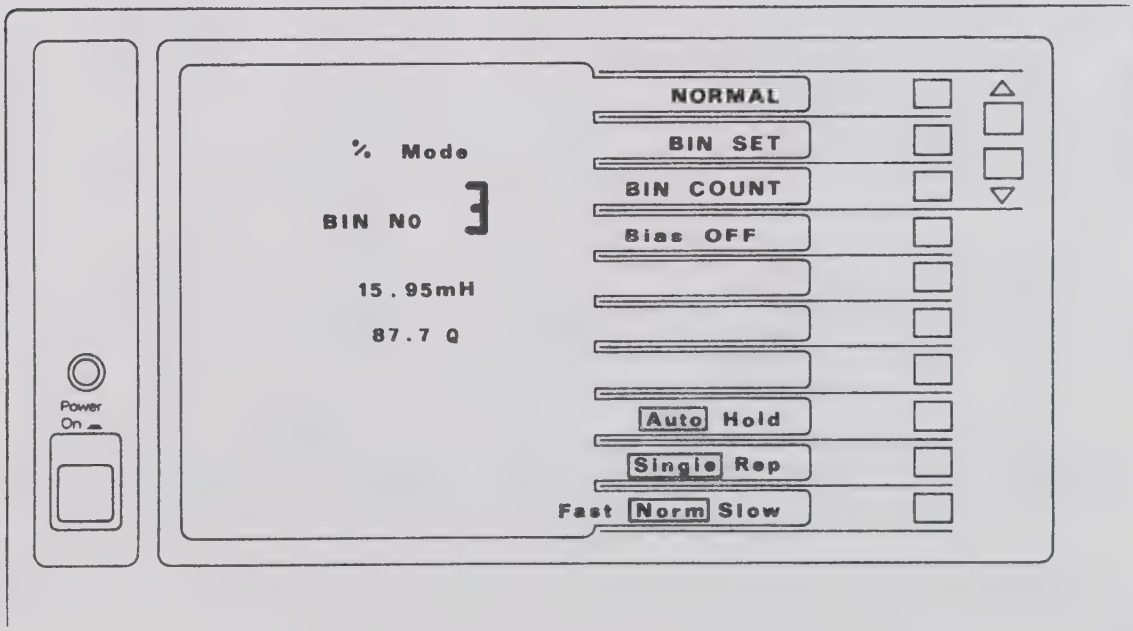


Figure 25 BIN SORT

4.Ø6 BIN SET (Continued)

Once satisfactory sets of limits and units are established, test items can be assessed by selecting BIN SORTing mode or BIN COUNTing mode.

Note the following points about BIN SET operations:-

a) The limits do not have to be symmetric.

b) The limits do not have to be unique. If there are more than one of a particular value, that with the lower bin number will be considered first.

c) When bins 1 to 8 are used for inductance or capacitance, bin Ø is used for MINOR TERM rejects. The rejects occur if the measured magnitude is below the selected limit (in the case of Q or parallel resistance), or above the selected limit (in the case of D or series resistance).

d) Bin 9 by default is for measurement results outside the limits of bins Ø to 8 inclusive.

4.Ø7 BIN SORT

The BIN SORT mode operates under SINGLE SHOT and REPetitive modes. In use, the screen display shows the result of the current measurement and the corresponding individual classification; see figure 25. Note the provision of soft-keys for direct switching to NORMAL, BIN SET and BIN COUNT.

A mis-match message will be displayed if either the units for BIN Ø limits (MINOR term) or units for the BIN 1 to 8 limits (MAJOR term) do not match the units set for NORMAL measurement. Hence even if BIN Ø is not being used, it must be given a default limit e.g. Q=1, which matches the NORMAL mode, otherwise the BIN SORT function will not operate.

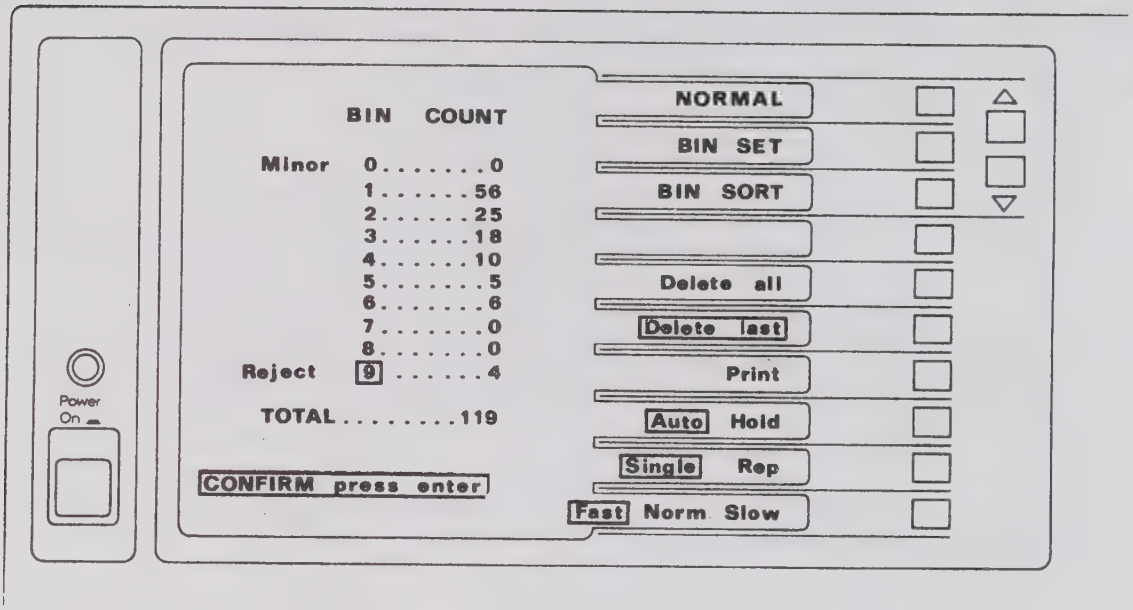


Figure 26 BIN COUNT (match)

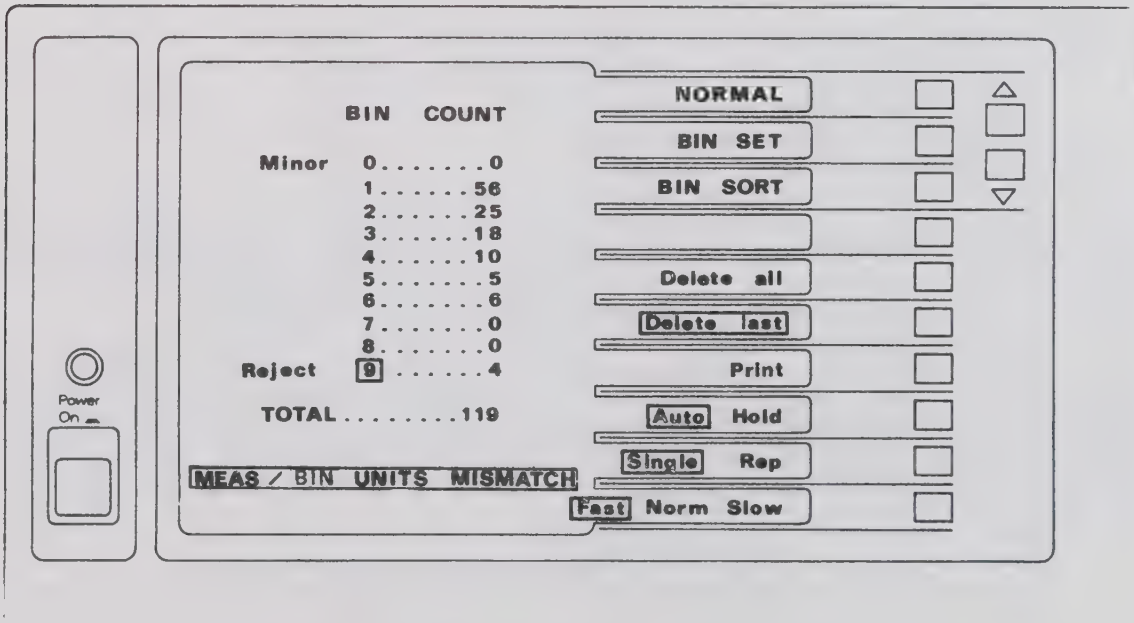


Figure 27 BIN COUNT (mis-match)

4.Ø8 BIN COUNT - Data Logging

BIN COUNTing operates under SINGLE SHOT mode. (It also operates, transparently to the user, when BIN SORT is used in SINGLE SHOT mode.) The screen displays data for all bins simultaneously, together with a batch total. Each measurement, as made, is allocated to the appropriate bin.

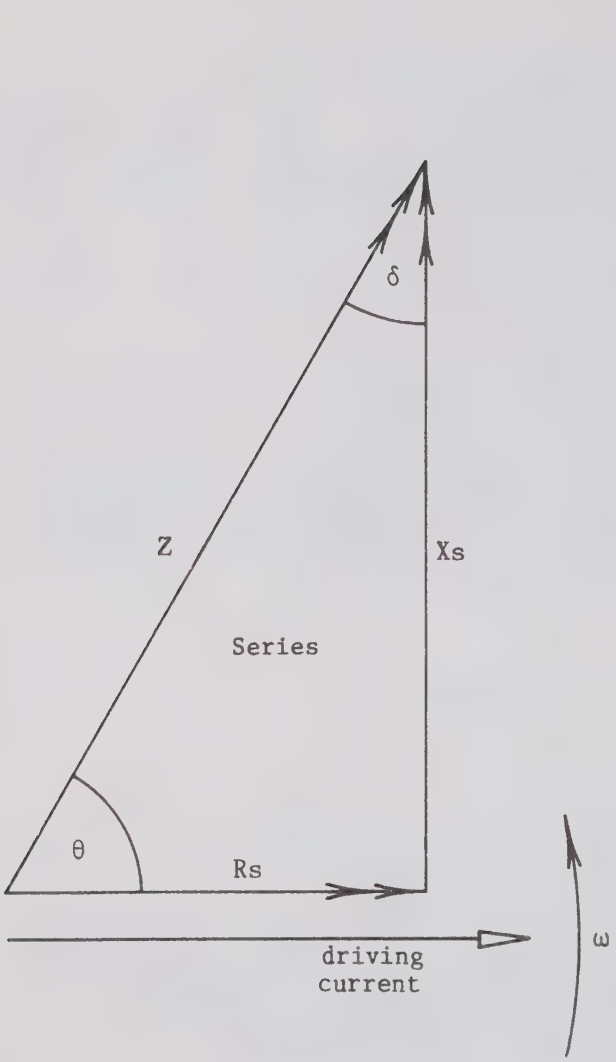
All BINning data stay in non-volatile memory until they are deleted. Hence the DELETE ALL key is used when setting-up for a new batch.

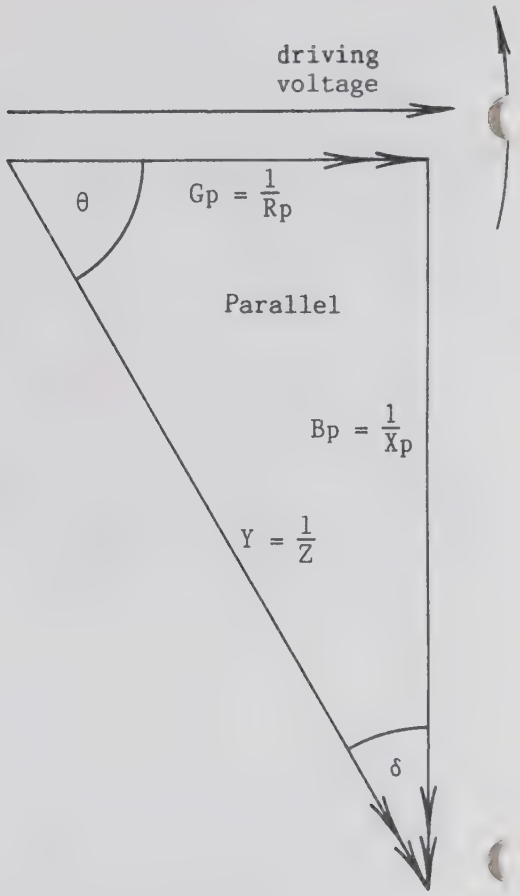
The DELETE LAST key is primarily meant for erasing the measurement result for a wrongly connected component.

Confirmation of a delete function has specifically to be given via ENTER (on the key-board) before the function is put into effect. The verification request is illustrated in figure 26. Note that there were four rejects on MAJOR TERM , none at all on MINOR. Also note the provision for direct switching to NORMAL, BIN SET and BIN SORT.

Figure 27 illustrates the situation where the settings for nominal and measurement units differ. This type of operator error can arise in BIN SORT and BIN COUNT modes, and happens from incompatibility of the units for BINs Ø and 1 to 8 and the units for NORMAL measurement. The analyzer maintains a constant check for this kind of error and a warning is issued if necessary.

The PRINT soft-key legend appears on the BIN COUNT display if the RS232C option is fitted or if the GPIB option is fitted and operating in PRINT ONLY fashion. See appendix B section 6.4 for details.





$$Q = \frac{Xs}{Rs} = \tan(\theta)$$

$$D = \frac{Rs}{Xs} = \tan(\delta)$$

$$Q = \frac{1/Xp}{1/Rp} = \tan(\theta) = \frac{Rp}{Xp}$$

$$D = \frac{1/Rp}{1/Xp} = \tan(\delta) = \frac{Xp}{Rp}$$

Figure 28 Impedance/Admittance Vector relationships

4.Ø9 ADVANCED USAGE

4.Ø9.Ø1 BASIC THEORY

A passive linear complex circuit presents to alternating currents an impedance which is a function of frequency. At any one frequency, the impedance can be represented by two components - resistance and reactance - or as a polar function having magnitude and phase angle. The reactance may be inductive or capacitive corresponding to +ve or -ve phase angles respectively in the polar configuration. The theoretical values of the components for extremes of frequency may not be practically realisable, but the following definitions hold:-

a) Polar parameters are impedance (Z) and phase angle (θ).

b) The impedance may be represented by either a series or parallel circuit - a resistance (R) and a reactance (X).

c) Current passing through the reactance results in stored energy, but current passing through the resistance results in dissipated energy. These two energy terms are related by the quality factor Q or dissipation factor D as defined below.

d) For the series case $R = Z \cos(\theta)$ and $X = Z \sin(\theta)$

where $Z^2 = R^2 + X^2$

i.e. $\tan(\theta) = X / R = Q = 1 / D$

e) For the parallel case $R = Z / \cos(\theta)$ and $X = Z / \sin(\theta)$

where $(1 / Z)^2 = (1 / R)^2 + (1 / X)^2$

and $\tan(\delta) = X / R = D = 1 / Q$

f) For the energy terms:-

$Q = X / R$ (series)

or $Q = R / X$ (parallel)

and $D = 1 / Q$

g) For inductances, $X = \omega L$

and for capacitances, $X = - 1 / (\omega C)$

where $\omega = 2 \pi f$ (frequency)
and the '-' sign represents a voltage phase lag with respect to current as opposed to a leading phase for inductances.

h) Diagrams representing these relationships are in figure 28, opposite.

Section 4.Ø9.1Ø covers the effects of self-capacitance and resonance.

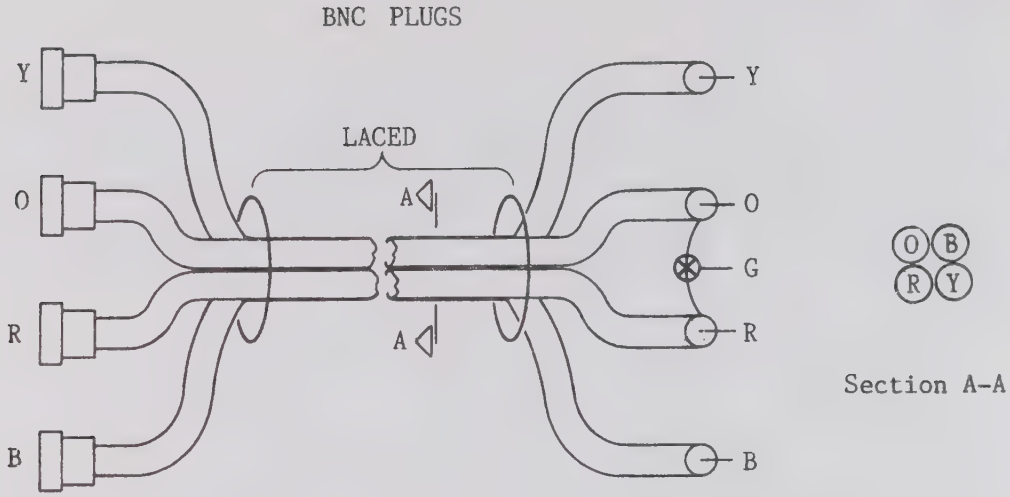


Figure 29 Test Lead arrangement

4.Ø9.Ø2 CONNECTIONS

Measurement connections may be 2, 3 or 4-terminal. The CONNECTIONS display, figure 19, shows some common arrangements. Choose 2-T for non-critical work, the guarded 3-T arrangement for in-circuit and high impedance measurements, and 4-T for low impedance work. A guard-wire at ground potential is available for guard or screen connection, see above. Note the lead bundling. Choose frequencies to minimise extraneous effects if measuring small impedances.

a) Impedances (at test frequencies) within 1ØØohms and 1Økohms are suited to 2-T connection. Unscreened leads should be shorter than approximately 15cm long. Longer leads should be separately screened; use a common connection of both braids ('RED' and 'ORANGE' leads) at the test item end. The crocodile clip accessory 15Ø5 is recommended.

b) 3-terminal connections remove the effect of shunt capacitance of the connecting leads. The common point of the shunting components should be connected to the common point of the braids on the 'RED' and 'ORANGE' leads. The crocodile clip accessory 15Ø5 is recommended.

c) 4-terminal connection circumvents series resistance of the leads, and diminishes series inductance effects. Stable lead positioning is important when measuring low value inductors. Long leads worsen series errors. The KELVIN clip-lead accessory 16Ø5 is recommended.

d) Connect transformer windings with crocodile clip leads (2-T fashion); apply ratio correction (section 4.Ø9.Ø7) if the primary winding impedance is low. (No correction is required in this respect for MUTUAL inductance measurements.) The errors are due to shunt impedances. A reverse-connected winding will lead to a negative reading for turns or ratio. See section 4.Ø3 for further details.

4.Ø9.Ø2 CONNECTIONS (Continued)

e) Braid screening of the 'RED' and 'ORANGE' leads should be joined at the test item end. Connect the common point to component guards and/or screens. The 'BROWN' and 'YELLOW' leads' braids must NOT be connected at the test item end. All the braids are earthed internally at the instrument end. The KELVIN clip-leads accessory is constructed so; it has a 'fifth' (GREEN) wire (with a crocodile clip) for use as the common connection; see figures 2 and 29.

Leads made for special measurement situations may present problems when the unknown impedances are either low or high. Any extra series resistance and shunt capacitance will result in additional errors. The type of error will depend on the connection configuration.

Extending lengths of measuring cable has two adverse effects:-

1) Resistance of the central conductor reduces the effectiveness of the 4-T configuration; degradation is linear with lead resistance. For example: After trimming with connections of Ø.45ohms/lead, variation in contact resistance will be reduced by 1ØØ times compared with a 2-T connection.

2) Cable capacitance increases measurement errors at high impedances and high frequencies. A capacitance of 1.5nF/cable gives performance within 2:1 of claimed specification on the highest measurement range available at any level/frequency combination. At lower ranges and at a frequency less than 5kHz errors are negligible. Where use is restricted to impedances greater than about 1ØØ ohms the 2-T configuration may be used with capacitance up to 3nF/cable.

Bundling the cables affects low impedance TRIM, mainly on inductance. The arrangement shown in figure 29 is preferred.

4.Ø9.Ø3 MANUAL RANGE SELECTION (and DRIVE LEVELS)

Manual range selection (RANGE HOLD mode) is by codes 1 - 7, see section 3. Manual ranging for transformer tests is not feasible. The present range can be determined via the key-board using CODE 9; see section 7.Ø2.

Use of the RANGE HOLD is recommended for the following measurements:-

a) Inductors of extreme non-linearity; these may lead to the AUTO-RANGE routines hunting, trying to resolve inductance variations caused by changes in drive levels.

b) Impedance values near to a range boundary may lead to the drive switching between voltage and current modes when successive test items are similar in value. (Hysteresis in the drive decision system avoids this problem when any one component is being measured.)

Small variations in drive level at the connections, as the unknown impedance changes, arise from regulation inherent in the source. The effect is insignificant except when the unknown is about 1Øohms.

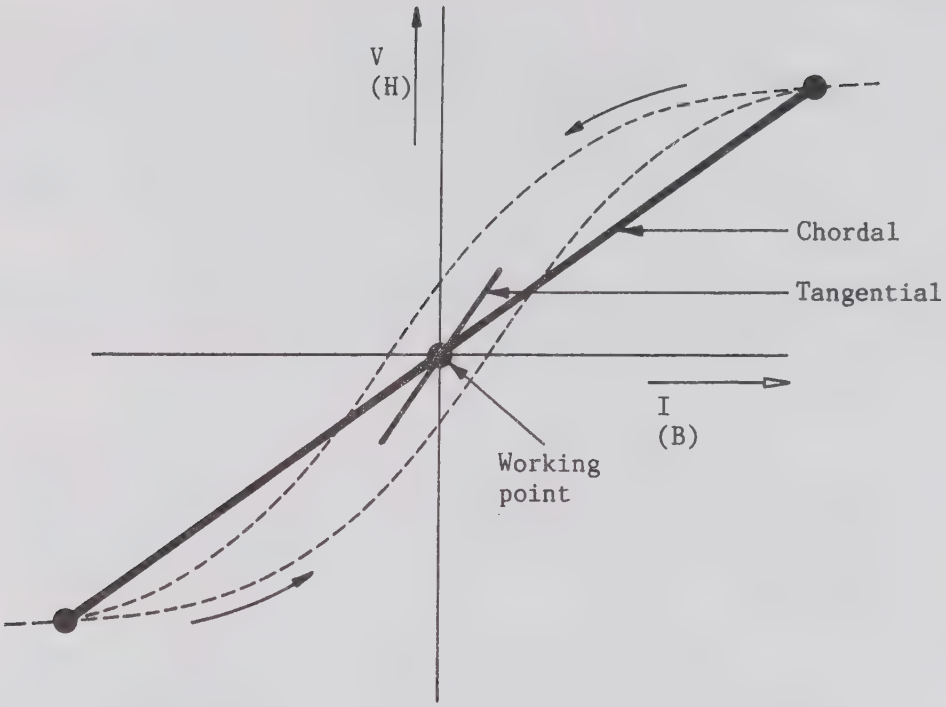


Figure 3Ø V/I Characteristic of Iron-cored Coils. Measurement is integral of curve - between chordal and tangential values

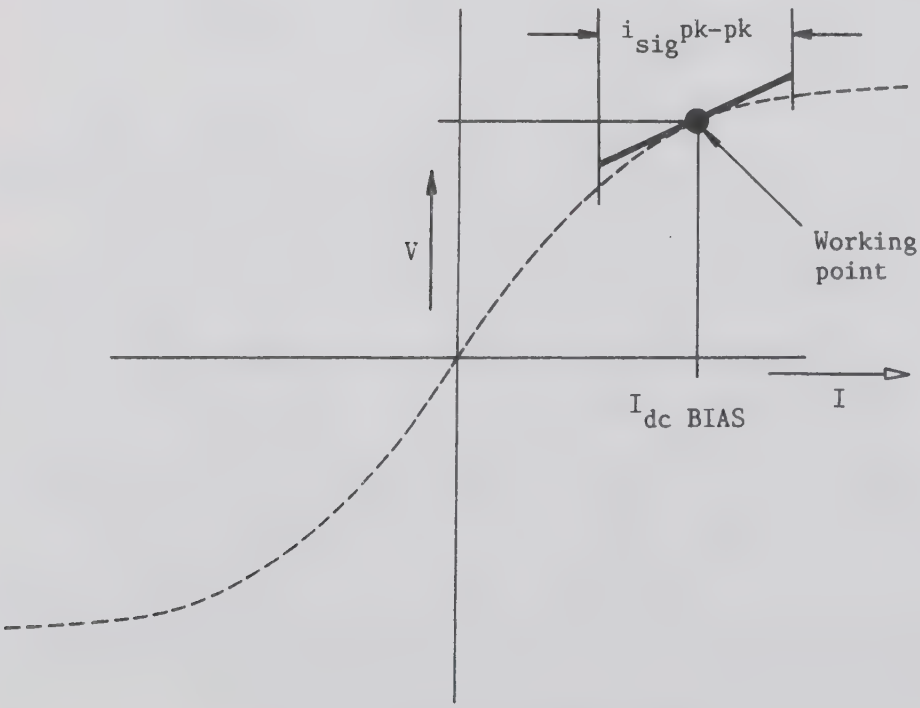


Figure 31 High Flux measurement
Small i_{sig}: Large $I_{dc\ BIAS}$

4.Ø9.Ø4 IRON-CORED (and FERRITE-CORED) INDUCTORS

Measurement accuracy, in part, depends on the linearity of the test item response. Gapped cores usually give good linearity. The level and frequency can be chosen to suit the application.

Un-gapped cores always cause non-linearity. Inductance usually rises with increasing flux level until saturation is approached. Once saturation is reached, the inductance falls rapidly as drive level continues to rise.

Non-linearities arise from the curved nature of the V/I characteristic of iron-cored coils. The 3245 analyzer filters out the distortion, consequently it measures the integrated value of the curved characteristic, see figure 3Ø.

Iron-cored inductors, including transformers, are susceptible to disaccommodation arising from electrical, magnetic, mechanical and thermal shock; any of which can produce transient or permanent change in inductance. The effect is worst in un-gapped iron-cored inductors at low drive levels. Obviously the shocks can be caused by large changes in level of the driving signal, it is therefore advisable to change the drive level in small increments. The transient changes have long recovery time-constants, so successive measurements (at the same conditions) on a shocked inductor, will show unidirectional changing values. The time taken for the overall change of level, will depend on the component itself and the accuracy required.

A change in frequency may lead to a change in drive mode e.g. from current to voltage. Since constant flux arises from constant current application, not constant voltage, note the displayed drive condition.

The 3245 uses low power levels. High operational flux conditions are beyond the specification but high level performance can be indicated using a combination of ac drive and dc BIAS, see figure 31. The working point slope will differ from that for full ac drive condition, see figure 3Ø. This technique allows, for example, flux saturation levels to be found. Note that an external safety link must be fitted (on the rear panel) for BIAS operation, see 4.Ø9.Ø8.

Pick-up of power-supply frequency can be minimised by avoiding strong external fields (this includes keeping the test item away from the 3245) and by grounding the core. (There is a ground connection with the clip leads.) Effects of the pick-up can be minimised by running at SLOW speed.

4.Ø9.Ø5 AIR-CORED INDUCTORS

Problems in measuring air-cored inductors can be minimised by exercising care over the following points:-

a) Keep the coil away from supply transformers and metal in general.

b) Keep the coil away from TV scan coils - at the LH side of 3245.

c) If power-supply or TV scan frequencies are a nuisance, use the SLOW measuring speed, the maximum available drive level and avoid measuring at the local supply frequency and its harmonics.

d) Q is often low due to series resistance. For best results in Q measurement, choose the highest possible frequency consistent with avoiding self-capacitance problems - see section 4.Ø9.1Ø.

e) Operate at 1ØkHz in series configuration for best accuracy in inductance measurement.

4.Ø9.Ø6 LOW VALUE INDUCTORS

The analyzer measures the difference between the inductance of S/C trimming and the test item fitted into the same location. Therefore stable lead arrangements are essential for low inductance measurements; use of the component fixture, accessory 1ØØ5, is recommended. When using the fixture, S/C trim is achieved by placing a wire across the jaws.

A 5cm length of 1mm wire has an inductance of Ø.Ø5µH.
A 5cm length of 2mm wire has an inductance of Ø.Ø4µH.

The Q is always low but self-capacitance is not a problem at the 3245 measurement frequencies. For best inductance measurement results, work at 1ØkHz in series configuration.

4.Ø9.Ø7 TRANSFORMER MEASUREMENTS

Transformer turns ratios are measured in 2-terminal fashion thereby presenting the problems which 4-terminal techniques aim to overcome. In essence the effects of measurement lead impedances and transformer shunt impedances cannot be avoided.

Turns-ratio is assessed by comparing the measured open circuit output voltage with a selected driving voltage. Hence magnetising current flowing in the primary winding renders the observed turns ratio less than the true value; the true ratio is determined from:-

$$\text{Ratio(true)} = \text{Ratio(obsvd)} \cdot \sqrt{1 + (Rt/\omega Lp)^2}$$

Where Rt is the sum of lead and primary series resistances,
Lp is the primary inductance measured at ω and
ω is $2\pi \cdot$frequency of measurement.
Supplied leads:- total series resistance typically less than Ø.25ohm.

The effect is most serious at frequencies where $\omega Lp < 1ØRt$ and, for a given set of leads, is worse for low impedance transformers.

4.Ø9.Ø7 TRANSFORMER MEASUREMENTS (Continued)

Many audio transformers self-resonate within their working frequency band. Measurement errors will be minimised by working at the resonant frequency which can be found by separate measurements on the primary impedance, seeking where the phase angle changes from positive to negative.

Example of correction at a 34% resistance/reactance ratio.

Transformer, wound 65:1Ø; measured at 5ØØHz
Observed ratio = 65:9.5
Lp = 35ØµH, Rdc = Ø.121Ω, Lead resistance = Ø.25Ω

Correction factor $= \sqrt{1+(Ø.121+Ø.25Ø)^2/(2\cdot\pi\cdot5ØØ\cdot35ØE-6)^2}$
$= 1.Ø5539$
Corrected Sec.wndg = 1Ø.Ø26
Corrected ratio = 65:1Ø.Ø3

The correction for parallel resistance is given by:-

Ratio(true) = Ratio(obsvd)•(Rppr + Rt)/Rppr
Where Rppr is the measured ac parallel primary resistance.

The overall effect of the two ratio corrections is given by their product (or sum, if percentage terms are used). If the lead resistance to impedance or inductance ratio is liable to produce errors of greater than Ø.5% then the 3245 outputs a warning:-

Δ LO-Z INPUT Δ

The 2-terminal primary impedance can be measured at any specific drive conditions simply by disconnecting the secondary and selecting NORMAL operation with Z display.

Overload may occur at frequencies having prominent harmonics near resonance of the primary inductance and the effective self-capacitance of the transformer. Therefore in order to minimise measurement errors, choose a suitable frequency and drive level.

For step-up transformers, the measured secondary voltage is limited to 5V rms.

Use of the AUTO-RANGE function is more complex for transformers. The display is blanked while the readings settle. Measurement of batches of transformers of similar ratios under similar frequency and drive level conditions may well be simplified by working in the RANGE HOLD mode, see figure 12. Manual ranging for transformer tests is not feasible.

Leakage inductance can be measured for a pair of windings by short circuiting one and making a NORMAL inductance measurement on the other. The result is independent of their roles.

4.Ø9.Ø8 INTERNAL dc BIAS FACILITY

The dc BIAS facility is a constant current which is injected in parallel with the ac drive signal. The internal source is rated to 1Amp; the optional external BIAS unit is rated at up to 2ØAmp for measurement purposes up to 2ØkHz.

For safety purposes the current cannot be turned ON until after a test item with an ac impedance of less than 41kohm is connected. To avoid shock hazard do NOT remove the coil during a measurement with the dc BIAS ON. Turn OFF the BIAS current and wait for the 'BIAS ON - SHOCK HAZARD' warning to extinguish before disconnecting the test item. Also note that the 3245 turns OFF the current when the test ac impedance is too high.*

The 3245 changes current levels in a ramped fashion. When a steady level has been achieved the message:-

DC CURRENT NOT SET

is extinguished. The settling delay lets the Analyzer recover from overloading caused when BIAS is switched ON. The delay is a function of the measuring range selected. Ranges 1 to 4 settle in 2 seconds, range 5 in 5.5 seconds and range 6 in 7 seconds. If the impedance to be measured is above the normal range 4 limit of 64Øohms, it may still be measured on range 4 with reduced accuracy to obtain fastest settling. For fastest response, use RANGE HOLD and select an appropriate range using the CODE function. Range 7 is not available with dc BIAS. Disaccommodation occurs with iron-cored inductors, see section 4.Ø9.Ø4.

The maximum permissible BIAS induced dc voltage drop depends on the ac drive level. Avoid 'bottoming' the combination of BIAS and drive signal. When the sum of dc and peak ac (1.414 x Vrms) is greater than 13V nominal the message:-

EXCESS VOLTAGE DROP

is displayed. (This value is nominal only. The internal supply is unregulated and hence varies with the ac supply voltage.)

Note that use of the dc BIAS facility inherently reduces the measurement accuracy, see figure 5.

Fit a safety link to the Analyzer whenever the internal BIAS facility is to be used. Before measuring inductors which may be damaged by dc BIAS e.g. tape heads, microphone inserts etc., remove the link as a safety precaution. Terminals for the link are on the rear panel; if BIAS ON is selected with the link absent, 'EXCESS VOLTAGE DROP' is reported.*

When operating with voltage drive, it is possible to select conditions giving ac current values very small compared with the dc current bias. This situation can give rise to excessive measurement errors or noise. To obtain the accuracy figures shown in fig. 5, the rms ac current should be not less than 1% of the selected dc bias value. This current can be calculated, or measured directly as a minor term with Z selected. For very high impedance inductors, it may not be possible to achieve the required conditions, in which case the highest available drive voltage must be selected.

* New safety features: see page 1:6.

4.Ø9.Ø9 Rdc MEASUREMENTS

The two dc resistance ranges were designed to cover the inherent resistance of inductor windings. The Analyzer limits the drive current to 16mA maximum and the drive voltage to 1ØØmV - thereby avoiding self-heating and the magnetising of iron-cored inductors.

When in AUTO-RANGE mode, the LOW range is selected for resistance values below 2ohms. The NORMAL range operates for higher resistance values; see section 3 for full specification. When in RANGE HOLD mode, LOW or NORMAL Rdc ranges may be selected by codes 21 or 22 respectively.

Accuracy within the specified ranges is Ø.5% at NORMal speed; outside those ranges accuracy is lower. For best LO-Z and HI-Z coverage use SLOW speed.

4.Ø9.1Ø SELF-CAPACITANCE and RESONANCE

Self-capacitance resonates with inductance at a frequency f_0. At frequencies below resonance, the effective inductance is increased. Above resonance the impedance becomes capacitive, giving a negative inductance reading. The values of each of the two L components in the expressions below, may be either positive or negative. The signs must be included with the values.

To establish the effect, measurements must be made at two frequencies. If inductances L_1 and L_2 are measured at two frequencies f_1 and f_2 near resonance (in parallel representation), then the self-capacitance is given by:-

$$C_0 = \frac{(L_2 - L_1)}{L_2 L_1} \cdot \frac{1}{(\omega_2^2 - \omega_1^2)}$$

The resonant frequency is given by:-

$$f_0 = \sqrt{\left(\frac{f_2^2 L_2 - f_1^2 L_1}{L_2 - L_1}\right)}$$

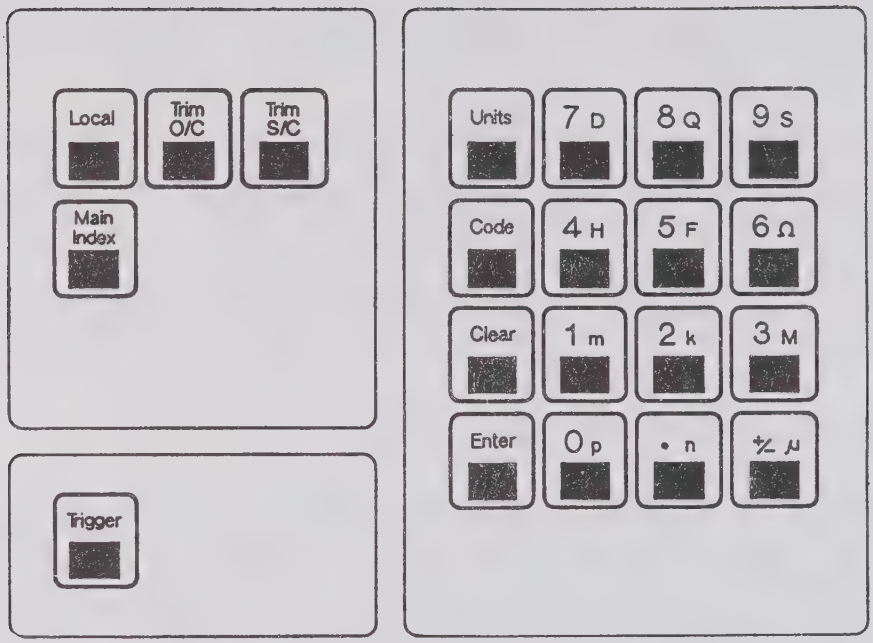


Figure 7 Main Function Keys and Key-Board

4.Ø9.11 DATA ENTRY KEY-BOARD

The data-entry key-board, illustrated in figure 7, uses a multi-function key-set permitting manual entry of data values, measurement units and control codes. The layout for digits keys is a common arrangement for hand-held calculators but the 'UNITS' key has a 'shift' purpose. When it is pressed the numeric keys change roles to units or multipliers. The alternative roles are:-

a) Top row; MINOR TERMs 'D' and 'Q'

b) Next row; measurement units 'H', 'F', 'Ω' (ohms)

c) The other two rows have normal value power multiplier symbols:-

Mega	$1Ø^{6}$	'M'
kilo	$1Ø^{3}$	'k'
milli	$1Ø^{-3}$	'm'
micro	$1Ø^{-6}$	'μ'
nano	$1Ø^{-9}$	'n'
pico	$1Ø^{-12}$	'p'

4.Ø9.11 DATA ENTRY KEY-BOARD (Continued)

The Keys in the left-hand numeric column are single function:-

d) UNITS key equates to 'shift'. Use it prior to keying a unit or multiplier e.g. H or m. Terminate mode with ENTER.

e) CODE implies a code number to follow; ENTER terminates the mode.

f) The CLEAR key erases any entry made since last use of ENTER.

g) Pressing the ENTER key accepts the entry just made (echo in data line), given that the present mode permits data entry.

Warnings:

Key-board data entry inhibits measurement. A leading decimal point is unobtrusive; easy to overlook if keyed inadvertently; the analyzer will wait for more data. Keyed data should be terminated or CLEARed.

Any process interupted by keying, recommences when keying ends.

Examples of keyed sequences (characters in [ ]) using the convention:-

U for UNITS, K for CODE, C for CLEAR and / for ENTER.

Example 1: Supply the analyzer with a value of 27.39mH.
(Assume that the code is suitably set)

[.] [Ø] [2] [7] [3] [9] [U] [H] [/])These two versions
)
[2] [7] [.] [3] [9] [U] [m] [H] [/])use U for multipliers.

Notice that at U the grating appears and then is overwritten by m.

The +/- key may be used before or after a value to change its sign.

If a mistake is made in a sequence, before pressing / (ENTER), press C (CLEAR) to restart the section. This would, for example, prevent an erroneous measurement being made while in REPetitive mode.

Confirm that the data entry line display is correct; re-key if not.

Example 2: Set the frequency to 1ØØkHz.
(Arrow display must be at frequency.)

[1] [Ø] [Ø] [Ø] [Ø] [Ø] [/]

[1] [Ø] [Ø] [U] [k] [/])These two versions
)
[Ø] [.] [1] [U] [M] [/])use U for Units

Example 3: Set a CODE value of 3245
(This code is always accepted; it sets/resets)
('electronic' lock on other key-board entries.)

[K] [3] [2] [4] [5] [/]

4.1Ø INTERFACES

4.1Ø.Ø1 RS232C INTERFACE: Printer

This option outputs measurement data in serial form i.e. suited to printers, via a standard 25-way 'D' connector. Data transfer rates, word lengt parity choices and pin connections are detailed in appendix B.

4.1Ø.Ø2 GPIB INTERFACE: Printer/Full Control

The GPIB option conforms to the IEEE Std. 488-1978 (including the 198Ø Supplement) in the following categories of allowable sub-functions:-

SH1	Source Handshake	- Complete capability
AH1	Acceptor handshake	- Complete capability
T5	Basic Talker, Serial Poll, Talk only, Unaddressed if MLA	
TEØ	No Extended Talker	
L4	Basic Listener, No Listen Only, Unaddressed if MTA	
LEØ	No Extended Listener	
SR1	Service Request	
RL1	Remote/Local Function	- Complete Capability
PPØ	No Parallel Poll	
DC1	Device Clear	
DT1	Device Trigger	- Complete Capability
CØ	Not Controller	

Available also, but not included in the IEEE 488 specification, is a sub-function which allows both REMOTE and LOCAL triggering of measurements by enabling the TRIGGER key. This mode is selected by the LOCAL TRIGGER ON command (see Appendix A, section B). LOCAL TRIGGER OFF inhibits this mode. No controller is needed in Talker Only mode when GPIB compatible printers are used

Full details of commands and output facilites are given in appendix A.

4.1Ø.Ø3 ANALOGUE OUTPUT OPTION (Ø - 1.ØVdc Full Scale)

The analogue option gives two dc outputs scaled Ø to 1V corresponding to the measured parameters in any operating mode. Zero and full scale values can be set via the front panel key-board. Details are provided in Appendix F.

4.1Ø.Ø4 BINNING HANDLER OPTION

The Handler option provides hand-shake signals and relay outputs for use with automatic handlers. It operates in BIN SORT and BIN COUNT modes. Details are provided in Appendix E.

4.1Ø.Ø5 EXTERNAL dc BIAS UNIT (OPTION 322Ø)

Internal dc BIAS current from the 3245 is limited to 1A maximum. The 322Ø dc BIAS option is rated for measurement purposes to 2ØA up to 2ØkHz. Several of these options can be used in parallel for BIAS levels up to 1ØØA maximum. In use the options and 3245 are stacked to keep the leads as direct as possible (dimensions are common). The analyzer controls all operations of the option, keeping its own internal 1A BIAS supply switched off (hence the 3245 BIAS safety link is not required). Full operational details for the external BIAS unit ar given in its handbook.

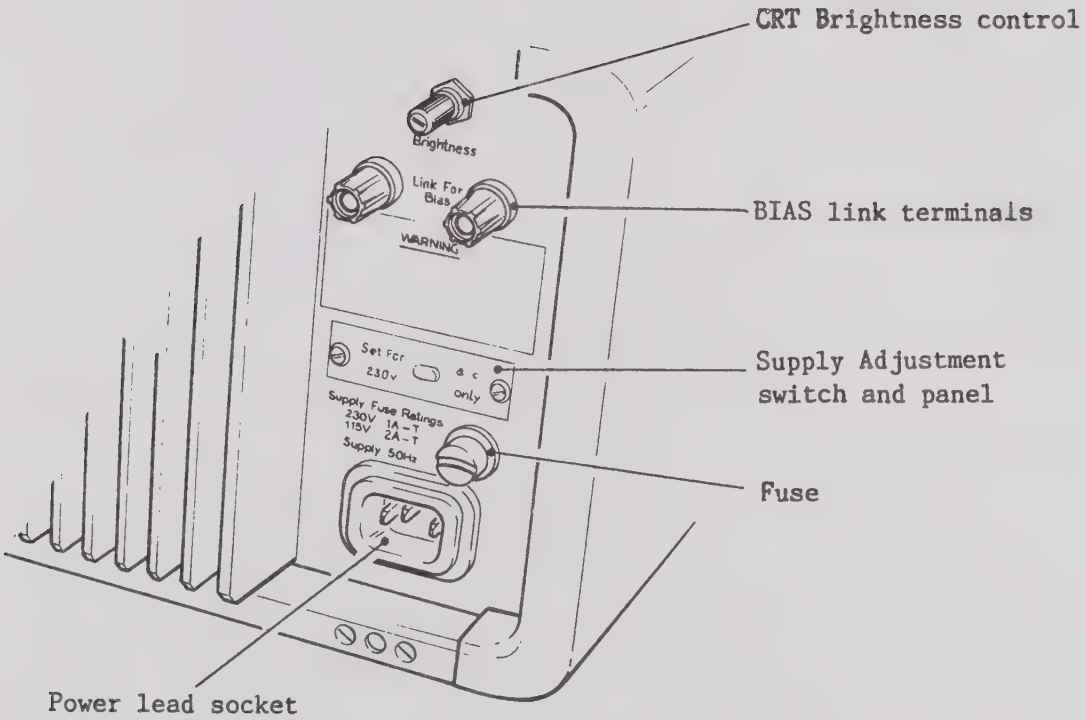


Figure 32 Backpanel

7 FUNCTIONS, TERMS and CODES

7.Ø1 FUNCTIONS and TERMS

Δ	Refers operator to handbook
δ	Loss angle; 'delta'
θ	Phase angle; 'theta'
ω	Angular frequency 'omega'
Accuracy charts	Contour charts relating measurement accuracy to frequency, drive level, dc BIAS and test component value
BIN COUNT	Mode for logging binning results
BIN SET	Mode for setting binning classifications
BIN SORT	Mode for binning operations
Binning	Component value classification MAJOR and MINOR TERM limits
Binning Handler	Component sorting equipment, 3245 controlled
C	Capacitance
D	Dissipation factor: $D=\tan(\delta)=1/Q$
DEVIATION	1) MAJOR TERM percentage difference between actual value and previously defined nominal 2) Mode for initial settings for above
Drive	Signal, ac or dc, applied to test item
f	Frequency
GPIB	See IEEE 488 (General Purpose Interface Bus)
Iac	Current drive
Idc	Direct Current bias
IEEE 488	A standard parallel interface system linking computers and peripheral equipment
KELVIN clips	Twin clip-leads; each clip having one jaw as part of the drive circuit, and the other as part of the sensor circuit; 4-terminal measurement conditions are implicit
L	Inductance
LIMITS	1) The boundaries for acceptance measurements 2) Mode for setting the above boundaries
Lm	Mutual inductance
LOCAL	Part of the GPIB option facilities; restores front panel operation when in remote control

7.Ø1 FUNCTIONS and TERMS (Continued)

MAJOR TERM	Z, Rdc For inductance and capacitance: L, C For resistance: R
MINOR TERM	/θ For inductance and capacitance: Q, D, and also loss resistance, Rac
N	Turns ratio: N=Np/Ns or Ns/Np
NORMAL	Mode for measurement of parameters of single windings
Np	Primary turns
Ns	Secondary turns
Parity check	Check performed at power-up to ensure that non-volatile data is valid
PRI	Primary
Q	'quality' factor: Q=1/D
Rac	apparent resistance to ac stimulus
Rdc	dc resistance
Rp	PRIMARY resistance
Rppr	Transformer primary parallel resistance
Rs	SECONDARY resistance
RS232C	A standard, unbalanced, asynchronous communication link for serial data
SEC	Secondary
Soft-keys	Variable function push-buttons, see figure 1
TRANSFORMERS	Mode for measurement of parameters of coupled windings
TRIMming	Compensating for parasitic errors due to the measuring leads
Vac	Voltage drive
Z	Impedance

7.Ø2 CODES

The CODE facility provides user access to functions which are not available via the labelled keys. Examples of this are manual selection of measurement range, locking or unlocking the key-board, enabling or disabling the printer output and self-test routines.

To implement any CODE function, press the CODE key followed by the appropriate number, then ENTER. See section 7.Ø2.Ø2 for a full list of available CODE numbers and their effects.

7.Ø2.Ø1 MANUAL RANGE SELECTION

Manual ranging, in place of AUTO-RANGE is possible except in TRANSFORMER mode. First ensure that HOLD is selected, then enter the CODE number corresponding to the ac measurement range required (see section 3.Ø1.Ø8 for details). For the dc resistance function use CODE 21 or CODE 22 respectively to select LOW or NORMAL measurement range. It is not necessary to have the corresponding ac or dc measurement function selected when entering these CODEs.

An on-screen range indicator is available in all measurement modes. Enter CODE 9 to obtain this function. The display will show, at the top left hand corner, the present range number. If Rdc is selected, the indicator will show either L or N corresponding to the LOW or NORMAL range.

Enter CODE 9 again to extinguish this indicator. Note that it will always be disabled at POWER ON.

7.Ø2.Ø2 CODES: EFFECTS and INTERPRETATIONS

CODE	EFFECT
Ø.1	Character set
Ø.2	Grid Test Pattern
Ø.3	Non-destructive RAM test) Later instruments
Ø.4	Key-board test) only
Ø.5	EPROM test - displays memory checks, old and new
1*	1)
2*	2)
3*	3)
4*	4) Range Number
5*	5)
6*	6)
7*	7)
9	Display/Extinguish present range number
9.1	Clears data in non-volatile memory
1Ø	Printer ON
11	Printer OFF
21	Rdc, low range - maximum 2Ω resistance
22	Rdc, normal range - above 2Ω resistance
3245	Set/Reset electronic lock on keys

Notes: (a) Range number/level limitations are detailed in the specifications, section 3.
(b) Codes marked (*) not applicable to TRANSFORMER mode; manual ranging for transformer tests is not feasible.

The setting of the 'electronic' lock is maintained during POWER OFF. Should the data in the non-volatile memory be found corrupted at POWER ON, the following display will appear, the asterisks identifying corrupted data blocks.

```
                                    *       NORMAL
                                    *  TRANSFORMER
                                    *    DEVIATION
PREVIOUS  SET UP                    *       LIMITS
CONDITION  LOST                     *      BIN SET
   FOR MODES                        *     BIN SORT
   INDICATED                        *    BIN COUNT
                                       CONNECTIONS
```

This condition may be forced by using CODE 9.1.

The MAIN INDEX button may be used to exit from the test displays.

Appendix A (Section A)

GPIB Interface for 3245 Analyzer

Definition of Command and Data Formats (Issue 1)

1. The GPIB Option

The GPIB option conforms to the IEEE Std. 488-1978 (including 198Ø Supplement) in the following categories of allowable sub-functions:-

SH1	Source Handshake	- Complete capability
AH1	Acceptor handshake	- Complete capability
T5	Basic Talker, Serial Poll, Talk only, Unaddressed if MLA	
TEØ	No Extended Talker	
L4	Basic Listener, No Listen Only, Unaddressed if MTA	
LEØ	No Extended Listener	
SR1	Service Request	
RL1	Remote/Local Function	- Complete Capability
PPØ	No Parallel Poll	
DC1	Device Clear	
DT1	Device Trigger	- Complete Capability
CØ	Not Controller	

Also available, but not included in the IEEE 488 specification, is a sub-function which allows both Remote and Local triggering of measurements by enabling the Trigger Key. This mode is selected by the LOCAL TRIGGER ON command (see Appendix A, section B). LOCAL TRIGGER OFF inhibits this mode.

2. COMMAND FORMAT

2.1 The command set (Appendix A, section B) contains both full commands and recommended abbreviations. No other forms should be used. The full commands are designed to generate self-documenting command strings.

2.2 Some commands require a numeric value to follow e.g. CODE 4; FREQUENCY 1E3). If this is omitted a command error will be reported.

2.3 Commands must be separated by a delimiter (;) with EOI or LF sent at the end of each command string.

2.4 Commands will not be implemented until EOI or LF is received. Commands will be executed strictly in the order in which they appear in the string.

2.5 Whilst a command string is being executed, no further commands can be accepted.

2.6 If a measurement is in progress when a command is received, the measurement will be aborted. The MESS? command (See Clause 4.3) is the only exception to this rule.

2.7 If a command error is encountered, subsequent commands in the string will be ignored.

2.8 The maximum acceptable string length is 256 characters. If this is exceeded a command error will be reported.

Appendix A (Section A continued)

Definitions (Continued)

2.9 A command string should contain not more than one TRIGGER command. This must be the last last command in the string, otherwise a command error will be reported.

2.1Ø Upper and lower case letters are interpreted as being the same.

2.11 Only commands which are normally available in the selected mode will be accepted. Otherwise a command error will be reported. e.g. 'NOMINAL' cannot be selected in NORMAL mode. Except that modes can always be directly accessed without first calling INDEX.

2.12 Numeric data may be integers, real numbers or exponential format. Use of non-numeric multipliers (k, p etc.) is not permitted. If used a command error will be reported.

2.13 Units following numeric data will be recognised by the first letter only although the full name may be used for self documenting purposes.

2.14 Functions which require confirmation when locally selected do not require confirmation before execution when called via GPIB.

2.15 If 'Bias On' is selected when the measurement terminals are open circuited, this is treated as a command error (See Section 3).

2.16 Under Local Control a safety feature is incorporated which automatically turns off the dc bias when certain error conditions persist for more than a few seconds. This function does not operate under Remote Control.

2.17 Code numbers less than 1 are reserved for self test routines. These are not available under Remote Control.

2.18 Code 9.1 should only be sent as an individual command as it has the effect of erasing all stored data.

2.19 The response of the instrument to Device Clear is equivalent to the Power Up condition.

2.2Ø Typical command strings for setting the instrument might be:

a) FREQ3ØØE3;LEVEL7ØØE-3V;L;R;SERIES;AUTO;NORMALSPEED;TRIG

B) BIN 1;HILIM 1Ø;LOWLIM-1Ø;NOMINAL 3E-6 FARADS;BINSORT;TRIGGER

3. COMMAND ERRORS

3.1 If a command error occurs, SRQ will be generated. Types of command error will be encoded in the Status Byte (in response to a Serial Poll). See Appendix A, section C.

3.2 'Nearest Available' values will be implemented but reported as a command error.

3.3 When sending a.c. signal levels the units (V,A) must be included. If they do not match the current machine status, command error will be reported.

Appendix A (Section A continued)

Definitions (Continued)

4. DATA Output

4.1 Output consists of measurement results and displayed messages. The messages will be encoded as a single numeric value (see Appendix A, section D).

4.2 Output comprises four numeric values. The first value will be the encoded messages. The remaining three values will be the results from measurements. These results will be sent in the order in which they appear on the screen, top to bottom.

4.3 The encoded messages can be output at any time, independent of the measurement status, by sending the MESS? command. In this case the three data values will be set to Ø.ØØEØØ.

4.4 Each value will be output separately. Each will terminate with CR followed by LF or EOI.

4.5 All values output that are surplus to the displayed measurement mode will have value Ø.ØØEØØ.

For example: NORMAL mode which usually displays two results the fourth value will be Ø.ØØEØØ.

4.6 Numeric results will be in Engineering Format (i.e. exponential format where exponent is a multiple of 3) with no units, of variable length corresponding to screen display.

4.7 If an OVERRANGE results, the value 999.9E15 will be sent.

4.8 At the end of any Trim sequence the encoded message value will be output with the three data values set to Ø.ØØEØØ.

4.9 If data is available for output when not addressed to talk SRQ will be generated. Only one SRQ will be generated for the 4 data values. 'Output Data Available' is indicated in the Status Byte (in response to a Serial Poll). See Appendix A, section C.

4.1Ø Sometimes measurement is not possible because drive levels have not been established. In this case the instrument responds by outputting the current encoded message set with the three data values set at 999.9E15.

4.11 If the instrument enters the listen state with any output data outstanding then this data will be discarded.

4.12 If a serial poll is received when the instrument is busy, the Busy condition is indicated by the Status Byte (See Appendix A, Section C). Busy conditions include processing commands, waiting to start a measurement, measurement in progress, outputting data.

Appendix A (Section A continued)

Definitions (Continued)

4.13 The result LOW PASS HIGH as displayed in the LIMITS mode will be output as a decimal integer, with the following representations:

Ø = Units mismatch condition
1 = LOW
2 = PASS
3 = HIGH

4.14 To read BIN COUNT data use the command INTERROGATE. The instrument responds by outputting the encoded messages, followed by the contents of each bin in sequence from Ø to 9 followed by the total.

5. TALK ONLY STATE

5.1 This state is selected by setting switches on the GPIB option. When in this state output is to a 'Listen always' device.

5.2 Data output to the printer will be formatted as detailed by the RS232C printer option. See Appendix B, sections 5 and 6.

Appendix A (Section B)

GPIB COMMAND SET

The table below shows the instrument functions which are also the GPIB Commands and are fully self-documenting. The abbreviation is an acceptable short form. Either command is accepted by the instrument.

FUNCTION	ABBREVIATION
ABS	ABS
AUTO	AUT
ANGLE	ANG
BIAS ON	BSON
BIAS OFF	BSOF
BIN SET	BNSE
BIN SORT	BNSR
BIN COUNT	BNCO
BIN NO 'VALUE'	BN
BIAS 'VALUE'	BA
C	C
CODE 'VALUE'	COD
CONNECTIONS	CON
D	D
DELETE ALL	DALL
DELETE LAST	DLAS
DEVIATION	DEV
DOWN	DOW
FAST SPEED	FAS
FREQUENCY 'VALUE'	FRE
G	G
HIGH LIMIT 'VALUE'	HIL
HOLD	HOL
IAC	IAC
INTERROGATE	INT
INDEX	IND
KEYLOCK	KL
KEY UNLOCK	KU
L	L
LM	LM
LEVEL 'VALUE'	LEV
LIMIT 'VALUE'	LMT
LIMITS	LMS
LOCAL	LCL
LOW LIMIT 'VALUE'	LOWL
LOCAL TRIGGER ON	LTON
LOCAL TRIGGER OFF	LTOF
MESS?	M?

BIAS *50E-3 ← 50mA

Ex: ...;SIN;BIAS ON;BIAS 50E-3
or BIAS OFF 50mA
↑ SINGLE

*Note: Place BIAS after the SINGLE/REP Button. Reference p. 4:8

Appendix A (Section B continued)

GPIB COMMAND SET (Continued)

FUNCTION	ABBREVIATION
NEXT	NEX
NORMAL	NOR
NORMAL SPEED	NORS
NP/NS	NP/S
NS/NP	NS/P
NS	NS
PARALLEL	PAR
PRINT	PRI
Q	Q
R	R
RATIO	RAT
RDC	RDC
REPEAT	REP
RESET	RES
SAVE NOMINAL	SAV
SCALE OFF	SCF
SCALE ON	SCN
SET NP 'VALUE'	SNP
SET LIMIT 'VALUE'	SLI
SET NOMINAL 'VALUE'	SNO
SET ANALOG	SAN
SINGLE	SIN
SERIES	SER
SLOW SPEED	SLO
TRANSFORMER	TRA
TRIGGER	TRG
TRIM LM	TLM
TRIM OPEN CIRCUIT	TOC
TRIM SHORT CIRCUIT	TSC
UP	UP
VAC	VAC
Y	Y
Z	Z
%	%

Appendix A (Section C)

STATUS BYTE FORMAT

The status byte is formatted to indicate,

a) when the instrument is busy

b) when a message is displayed

c) when a result is available

d) when there is a command error

The defined bits are set according to the relevant condition or conditions. The bit map is as follows:

X S B R M O C C

'X' = not used and set false

'S' = Service request

'B' = Busy bit

'R' = Output data available

'M' = Message bit

'O' = Open circuit when 'BIAS ON' selected.

'CC' = Command error bits

The command error bits indicate the following command error conditions.

ØØ = No error

Ø1 = Syntax error

1Ø = not available

11 = buffer overflow

where Ø = false, 1 = true

Examples:-

Ø 1 Ø Ø Ø Ø Ø 1 = service request and command syntax error

Ø Ø 1 Ø 1 Ø Ø Ø = busy and there is a message displayed.

Appendix A (Section D)

ENCODED MESSAGE SET

The encoded message is a decimal value, where each digit or digit pair represents messages that appear on the instrument display.

The encoded message format is as follows:

I J K K L M N

Where N indicates range or trim errors

Ø = No message
1 = Range Error
2 = S/C Trim Error or Trim Failed:Out of Range
3 = Range Error plus S/C Trim Error
4 = O/C Trim Error or Trim Failed:Out of Range
5 = Range Error plus O/C Trim Error
8 = Lm Trim Error or Trim Failed:Out of Range
9 = Range Error plus Lm Trim Error.

M indicates the messages displayed on the warning line

Ø = No message
1 = Lo-z input
2 = Bias on Shock Hazard

L indicates messages relating to 322Ø Option.

Ø = No message
1 = 2ØA Unit: No Power
2 = 2ØA Unit Fuses
3 = 2ØA Over Temp.

The digit pair KK indicates the message on the message line

ØØ = No message
Ø1 = Nearest Available
Ø2 = Voltage Drive Selected
Ø3 = Current Drive Selected
Ø4 = Drive Level Reduced
Ø5 = DC Current Not Set
Ø6 = Excess Voltage Drop
Ø7 = Safety Bias Turned Off
Ø8 = Meas/Bin Units Mismatch
Ø9 = Meas/Nom Units Mismatch
1Ø = Level Too High
11 = (Code) Not Defined.
12 = AC Signal Changed

J is reserved for future expansion

Appendix A (Section D continued)

ENCODED MESSAGE SET (Continued)

I indicates data valid or invalid or check measurement status.

Ø = data valid
1 = data invalid
2 = measurement in progress

Examples:

ØØØ4ØØ2 = Drive Level reduced and S/C Trim Error

1ØØ9ØØ5 = Data invalid plus Meas/Nom Units Mismatch
plus Range Error and O/C Trim Error.

Appendix A (Section E)

INSTRUCTIONS FOR SETTING GPIB ADDRESS

The GPIB address and selection of talk only mode are set by SW1 on the GPIB option card.

To set the switch the option card must first be removed from the inductance analyzer; this may be done in the following manner:-

1) Release the top cover

2) Release the option card retaining screws

3) Release the option card from the flexible bus connector

4) Withdraw the option card

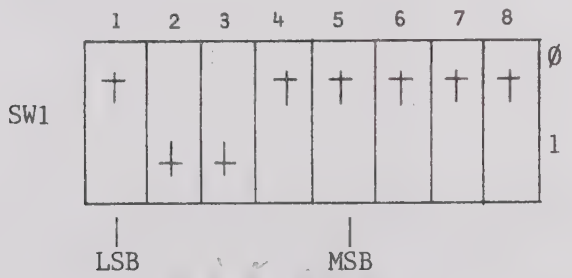
If it is desired to use the analyzer as a talk only device, i.e. without a controller on the bus, set SW1 pole 8 to 1. The other switch settings are unimportant.

If it is desired to use the analyzer with a controller.

1) Set SW1 pole 8 to Ø, i.e. NOT talk only.

2) Set the required device address in binary on poles 1 to 5 of SW1 where pole 1 is the least significant bit, the other poles represent succeeding bits, and a '1' is pole OFF.

e.g. With controller, device address 6



NOTE. The word 'Off' on the face of the switch (a standard item) should be disregarded. The BCD address required is set by moving the appropriate switch poles to the down position which is effectively the '1' setting. The diagram shows bits 2 and 4 (poles 2 & 3) operative, selecting address 6. It also shows pole 8 set to Ø for use of the Analyzer with a controller, which is the NOT talk only mode.

Appendix B (Section A)

RS-232-C Interface for 3245 Analyzer

DEFINITION OF RS232C OUTPUT OPTION

1.Ø General

When fitted with this option the instrument may be used to drive a printer or other recording device conforming to EIA Standard RS-232-C.

The option card is common to other Wayne Kerr equipment and there are links and switches on the card which have been set during installation to allow it to work in the instrument. Further switches on the option card set up characteristics of the RS232C link (data rate, parity checking etc.) which must have corresponding settings at the sending and receiving equipment before data can be transmitted.

2.Ø Setting Data Characteristics

To gain access to the option card first remove the instrument cover. S2Ø3 (located rear left) sets the characteristics of the transmitted data, which should match those of the printer. If the characteristics of the printer are not known, set all the switches to '1' initially. The most important characteristic which MUST correspond at each end of the link is the BAUD rate (switches 6, 7, 8). Note that the instrument must be powered 'off' whenever these settings are changed.

Switch 1
Sets data word length 1 = 7 bits, Ø = 8 bits.

Switch 2
Not used.

Switch 3
Sets number of stop bits 1 = 2 bits, Ø = 1 bit.
Setting Ø may give slight speed advantage with slow data rates.

Appendix B (Section A Continued)

DEFINITION (Continued)

2.Ø Setting Data Characteristics (Continued)

Switch 4

Most equipment uses a single parity bit to check for possible data errors. Switch 4 selects this function 1 = ON, Ø = OFF.

Switch 5

Parity check may be odd or even 1 = EVEN, Ø = ODD.

Note that equipments vary in their response to a detected parity error. They may print a standard character (?) or there may be a separate warning lamp. During setting up it is usually possible to run both ends of the link with parity 'OFF', but it should be used wherever possible to detect errors.

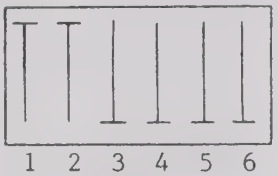
Switches 6, 7, 8

These set the Baud rate (data rate). The fastest rate which can be handled by the peripheral equipment should always be used.

Baud rate	6	7	8
11Ø	Ø	Ø	Ø
15Ø	1	Ø	Ø
3ØØ	Ø	1	Ø
6ØØ	1	1	Ø
12ØØ	Ø	Ø	1
24ØØ	1	Ø	1
48ØØ	Ø	1	1
96ØØ	1	1	1

3.Ø Cable Connectors and Data Flow Direction

The RS232C link is specified for linking peripheral equipment to computers, and some of the pin connections are different at the two ends of the cable. When driving a printer, convention dictates that the printer is peripheral, so the instrument option card should be wired as a computer. Ensure that S2Ø4 (located rear right) is set as follows.



S2Ø4

Appendix B (Section A Continued)

DEFINITION (Continued)

3.Ø Cable Connectors and Data Flow Direction (Continued)

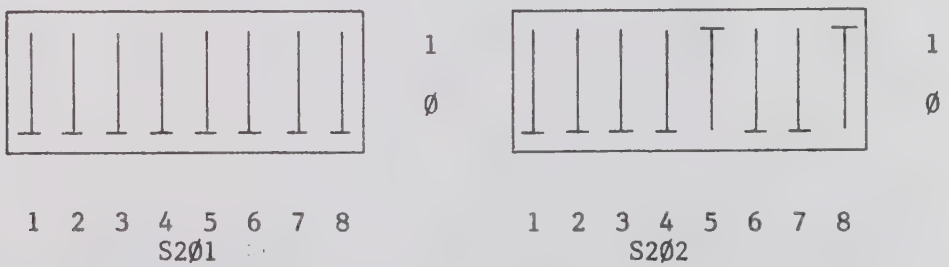
Connections for the 25-way output socket are as follows:

Pin	
1	Ground
2	Receive Data
3	Transmit Data
4	Clear to Send
5	Request to Send
6	Data Term Ready
7	Ground
8	Received Line Signal Det.
2Ø	Data Set Ready

Other pins are not used for the RS232C interface.

4.Ø Card Address

Behind and to the right of SK2Ø2 are two DIL switches S2Ø1 and S2Ø2. These are the card address and other characteristics to allow it to operate with the instrument. The correct settings for this option are shown below.



5.Ø Enabling the Printer Output

When the RS232C option is fitted, output can be enabled or disabled by entering 'Code 1Ø' or 'Code 11' respectively. When entered the timed message 'PRINTER ON' or 'PRINTER OFF' appears, indicating the current status of the output function.

Appendix B (Section A Continued)

DEFINITION (Continued)

6.Ø Printer Format

When operating in the Single mode the instrument will generate a single printed line up to 4Ø characters, terminated by CRLF.

```
1.ØkHz      1Ø.98µH     Ø.3622 Q
8ØØ Hz      16.ØØµH     Ø.2946 Q
6ØØ Hz      28.Ø6µH     Ø.2177 Q
```

The above example demonstrates the response to the measurement parameter that is being updated in Normal Mode measurements. The response is similar if the parameter being changed is LEVEL or BIAS.

6.1 Status

The status of the present measurement mode (except BIN SET) is output whenever the measurement mode, measurement function or any of the measurement parameters is changed.

```
  Freq   Level   Bias    Fast    Auto
1.ØkHz   1ØØmA    OFF     L Q     Par
```

The measurement mode is NORMAL.
The measurement functions are L and Q.
The measurement parameters are Frequency 1.ØkHz, Level 1ØØmA,
Bias Off, the speed is Fast and Parallel equivalent circuit selected.

Also the instrument is in the auto range state.

6.2 Output of Range Error

When operating in the Range Hold mode the measurement results may or may not be suppressed when a Range Error is indicated. When there is a Range Error the message 'RANGE ERROR' is output, terminated with CRLF, any displayed results are then output on the new line terminated with CRLF. If no results are displayed then the output is a blank line.

```
6ØØ Hz      -Ø.6nF      15Ø.Ø Ohm
6ØØ Hz      -Ø.4nF      15Ø.Ø Ohm
Range Error
6ØØ Hz      -Ø.4nF      851.5 Ohm
Range Error
6ØØ Hz       Ø.4nF      85Ø.Ø Ohm
Range Error

Range Error
```

Appendix B (Section A Continued)

DEFINITION (Continued)

6.3 Units Prefixes

As some printers only have upper case letters for units prefixes, the following convention is used.

F = femto $1Ø^{-15}$
P = pico $1Ø^{-12}$
N = nano $1Ø^{-09}$
U = micro $1Ø^{-06}$
M = milli $1Ø^{-03}$
K = kilo $1Ø^{+03}$
MG = mega $1Ø^{+06}$
G = giga $1Ø^{+09}$

6.4 Printing Bin Data

When BINSET mode is selected there are no facilities provided for making a measurement, also BIN COUNT has no result to output. Therefore when the RS232C option is fitted a new soft key is provided in the BIN COUNT mode. The key is labelled PRINT. The example below indicates the data that is output when the key is pressed. Indicated for each bin are the limits set and the number of items that had fallen into the bin. The example shows absolute limits (no Nominal).

Bin	High Limit	Low Limit	Count
Ø		Ø.Ø H	Ø
1	11Ø.Ø Ohm	1ØØ.Ø Ohm	2Ø
2	12Ø.Ø Ohm	11Ø.Ø Ohm	4
3	13Ø.Ø Ohm	12Ø.Ø Ohm	4
4	14Ø.Ø Ohm	13Ø.Ø Ohm	5
5	15Ø.Ø Ohm	14Ø.Ø Ohm	4
6	175.Ø Ohm	15Ø.Ø Ohm	13
7	2ØØ.Ø Ohm	175.Ø Ohm	8
8	25Ø.Ø Ohm	2ØØ.Ø Ohm	16
9	Reject		11
		Total	85

Appendix B (Section B)

Additional Examples

6.5 Further Printer Output Examples

Example 1. Single measurements

```
  Freq   Level   Bias    Slow    Auto
6ØØ Hz   1.ØØV    OFF     C R     Par

6ØØ Hz        -Ø.ØØnF     99.95Ø Ohm
6ØØ Hz         Ø.Ø2nF     99.955 Ohm
6ØØ Hz        -Ø.ØØnF     99.955 Ohm
```

Example 2. Updating the Level parameter in Normal Mode

```
  Freq   Level   Bias    Slow    Auto
6ØØ Hz   1.ØØV    OFF     C R     Par

1.ØØVac        Ø.1ØnF     99.955 Ohm
1.Ø5Vac        Ø.Ø2nF     99.95Ø Ohm
1.1ØVac        Ø.Ø4nF     99.955 Ohm
```

Example 3. Measuring an open circuit then short circuit in Rdc

```
Lev <1ØØmV DC Rdc       Slow    Auto

 OVER RANGE Ohm
 OVER RANGE Ohm
          4mOhm
          3mOhm
```

Example 4. Measuring Lm in Transformer Mode indicating Trim Errors

```
  Freq   Level   Lm   Norm    Auto
6ØØ Hz   1.ØØV

Lm Trim error
6ØØ Hz        7.Ø91mH
6ØØ Hz        7.Ø9ØmH
6ØØ Hz        7.Ø9ØmH
```

Example 5. Measuring Ns response to changing Np value

```
  Freq   Level   Ns   Fast    Auto
6ØØ Hz   1.ØØV   Np =  1ØØ

Np =  1ØØ          99.95
Np =  15Ø          149.9
Np =  2ØØ          199.9
```

Appendix B (Section B Continued)

Examples (Continued)

Example 6. Deviation Mode with Bias On measuring response to changing current

```
  Freq    Level    Bias     Norm     Auto
6ØØ Hz    1.ØØV     Ø A       L      Par
Nominal     9.268mH

  Ø Adc       -Ø.ØØ %       9.268mH
5ØØmAdc      -11.25 %       8.225mH
76ØmAdc      -21.41 %       7.284mH
```

Example 7. Limits Mode Absolute limits

```
Hi Lim =    385.Ø Ohm
Lo Lim =    315.Ø Ohm
Slow     Auto     Abs Mode

     33Ø.12 Ohm       PASS
     312.1Ø Ohm        LOW
```

Example 8. Limits Mode Percent limits

```
Hi Lim =     1Ø.Ø %
Lo Lim =    -1Ø.Ø %
Nom    =    35Ø.Ø Ohm
Slow     Auto     %    Mode

     Ø.Ø3Ø5 %         PASS
     11.46Ø %         HIGH
```

Example 9. Bin Sort

```
Norm     Auto     Abs Mode

Bin no. 4         Ø.Ø5nF       13Ø.92 Ohm
Bin no. 2         Ø.ØØnF       11Ø.92 Ohm
Bin no. 3         Ø.Ø5nF       12Ø.94 Ohm
```

Example 1Ø. Bin Sort with Meas/Nom units mismatch.

```
Norm     Auto     Abs Mode

MEAS/NOM UNITS MISMATCH
MEAS/NOM UNITS MISMATCH
MEAS/NOM UNITS MISMATCH
MEAS/NOM UNITS MISMATCH
```

Appendix C

Analog Bar Display

1 INTRODUCTION

The Analog Bar Display provides a visual representation of measurement results in the form of a horizontal bar of varying length. This function, which is useful for adjustment of preset components, is available only in Limits mode and is enabled/disabled by the Scale ON/OFF soft-key.

The Analog Bar Display incorporates two fixed marks, corresponding to the High and Low limits selected for Limits mode. Whenever these limits are entered, the horizontal scaling factor is adjusted accordingly.

Scale compression is applied for values above or below the pass limits, allowing a range of values up to 9 times the pass band to be displayed.

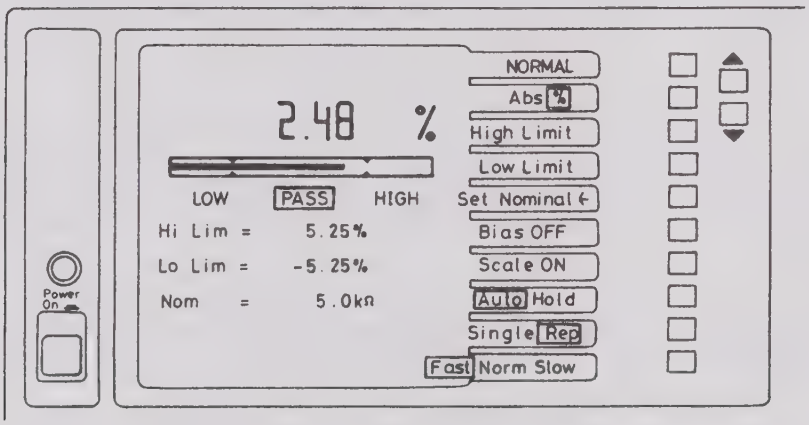


Figure C1 Limits Mode Display with Analog Scale ON

Appendix D

New Binning Software Specification

1 INTRODUCTION

The binning software has been revised. This Appendix gives details of how to operate the new Bin Set mode.

In the previous software, when binning on a major term of Capacitance (F) or Inductance (H), it was possible to specify only one limit on the minor term (for bin Ø). If this limit was set to, say, a Q of 1ØØ, then all components having a Q of less than 1ØØ would be grouped in bin Ø regardless of their major term, so making bin Ø a "reject on minor term" bin.

The new software enables a minor term limit to be specified independently for each of the bins Ø to 9 (bin Ø now being treated exactly as the other bins). This provides more flexibility and makes it possible to create classes of component, graded according to minor as well as major terms while making a single measurement.

2 OPERATION

Bin limits are entered in BIN SET mode, the high and low limits being specified absolutely or as a percentage of a given nominal. High or Low limits are entered by first pressing the appropriate soft-key and then entering the relevant limit. The NOMINAL value must be entered when binning is in percentage mode.

The bin to be updated is specified by moving the update cursor with the ▲ and ▼ keys. The update cursor is a box drawn around the specified limit of the current bin and it shows precisely which value will be altered by entering a number.

If major term units of F or H are selected, then the option is given of binning on minor term limits. The limit is entered after pressing the "Set Minor" soft-key. The minor term can only be specified absolutely with units of ohms, D or Q. If the user attempts to enter F or H then the entry will be ignored and the message "BAD MINOR TERM UNITS" will be displayed.

If the major term units are neither F nor H, then it is not possible to bin on minor term and the specified minor term limits will disappear and be replaced by a message. The "Set minor" soft-key label will also extinguish.

The RESET soft-key resets all three limits to zero for the selected bin. The NEXT key is used when entering limits in order, starting with Bin Ø High Limit, and selects the next Limit or Bin number in sequence.

3 USE

BIN SORT and BIN COUNT modes allow component sorting and update of bin information. The latter applies only in Single mode.

The binning is done by measuring a component and comparing the result obtained with the bin limits in order from Ø to 9. First the major term result is compared with the High and Low limits. If it does not lie between them, then the search goes immediately to the next bin.

The minor term result will only be tested against the major term limit if:

i) The major term units are F or H, and

ii) The minor term limit is not exactly zero.

If these conditions are not met, then the minor term is ignored and the component is "placed" in the current bin. Specifying a minor term limit of zero (the default value) provides a way of selectively ignoring the minor term for each bin.

The minor term result will be compared with the limit according to the label displayed at the head of the minor term limits column in BIN SET mode. For all of these labels x represents the minor term limit, ' ' means the result must be greater than the limit, and ' ' means the result must be less than the limit. The possible labels are listed below, together with the pass condition they represent:

Q	>	x	:	The Q of component must be greater than the limit
D	<	x	:	The D of the component must be less than the limit.
Rp	>	x	:	The parallel resistance must be greater than the limit.
Rs	<	x	:	The series resistance must be less than the limit.

Series or Parallel resistance is determined from NORMAL mode.

If the component meets the minor term conditions, it will be "put" in the relevant bin; otherwise, it will be tested against the limits of the next bin.

Sorting continues until either the component is placed in one of the bins Ø to 8 or, if none of them is found to be suitable, the component is placed in the reject bin, i.e. bin 9.

4 GPIB AND RS232 OPERATION

The only special points regarding the control of the instrument via the GPIB option are:

i) A command

BIN NO "value" (abbreviation BN)

to enable the controller to specify a bin number for updating.

ii) A command

SET MINOR "value" (abbreviation SMR)
enables the minor term limit to be specified. This will generate a command error if minor term limits are not available.

iii) If an attempt is made to set minor term units of F or H, then a command error will be generated along with the message number 13 in bytes KK of encoded messages, meaning "BAD MINOR TERM UNITS".

If the GPIB option card is set to talk only mode, or if an RS232 option card is fitted, then the PRINT command in BIN COUNT mode will generate a bin listing including the minor term limits.

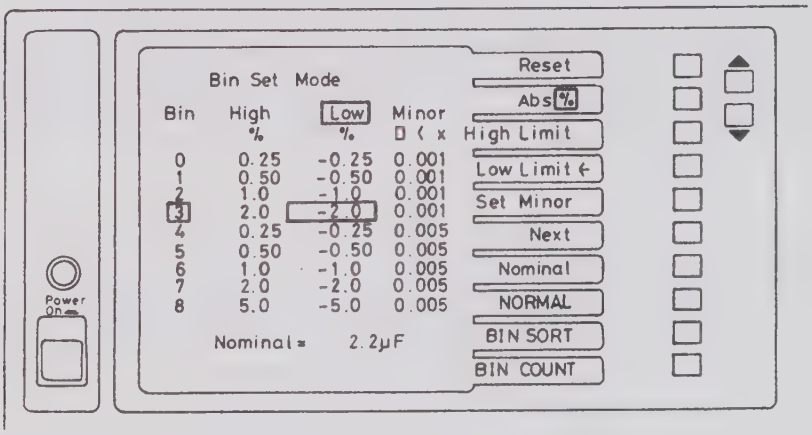


Figure D1 Sample Screen Display from Bin Set Mode

Appendix E

Standard Handler Interface (SHI)

1 INTRODUCTION

The SHI option card may be fitted into the option slot at the rear of a 3245. It will enable the instrument to measure a component, sort it into one of the eight bins according to the measurement results and then provide the signals for external bin handling hardware to physically "bin" the component. The interface supports up to eight external bins and provision is made for external bin handler hardware to trigger a measurement directly.

Note that in this Appendix "low" refers to a TTL logic level between Ø and Ø.8V and "high" is a TTL level between 2.4 and 5V.

2 OPERATION

When the SHI card is fitted into an instrument, there will be no noticeable difference in its operation. If Code Ø.7 is entered, the instrument will report whether or not it has detected the Interface with the messages 'BIN HANDLER FITTED' or 'BIN HANDLER NOT FITTED'. If the message 'NOT DEFINED' appears, then the software in the instrument does not support the Standard Handler Interface.

Results will be sent to the Interface only if all the following conditions are met:

i) The instrument is in Bin Count or Bin Sort mode.

ii) There is no MEAS/BIN UNITS MISMATCH error.

iii) Under Local operation, the instrument is set to Single.

3 INTERFACE DETAILS

The functions of the Interface lines are defined in Table E1. The two output signal lines $\overline{\text{BUSY}}$ and Bin Data Available ($\overline{\text{BDA}}$) will at any time assume one of four different states:

(1) Null State

The null state is defined as

$\overline{\text{BUSY}}$ low (i.e. instrument is busy)

$\overline{\text{BDA}}$ high (i.e. no data available)

All $\overline{\text{BIN}}$ lines high (i.e. no bins selected)

This state is adopted when the instrument is unable to perform binning due to one of the following reasons:

i) The instrument is not in either Bin Sort or Bin Count mode.

ii) There is a MEAS/NOM UNITS MISMATCH error.

iii) The instrument is in Local operation and not in Single shot mode.

iv) The instrument has not performed a measurement since the present mode was entered.

v) A DEVICE CLEAR has been sent by a GPIB controller.

When this state is detected by external hardware, it must be assumed that the current signals on the $\overline{\text{BIN}}$ lines are invalid and should be ignored and also that the instrument is not ready for an external $\overline{\text{TRIGGER}}$ signal.

When the above conditions have cleared, the next state will be entered.

(2) Ready for Trigger

In this state:

$\overline{\text{BUSY}}$ is high (i.e. not busy)

$\overline{\text{BDA}}$ is low (i.e. bin data is valid)

All $\overline{\text{BIN}}$ lines will be unchanged. If the previous state was a null then all bin lines will be high, meaning no bin selected, although $\overline{\text{BDA}}$ suggests that valid bin data is present.

This state indicates that the instrument is awaiting a trigger, whether from the front panel push button, a GPIB controller or from the $\overline{\text{TRIGGER}}$ line.

When the instrument receives a trigger it will respond by entering the next state.

(3) Busy

In this state:

$\overline{\text{BUSY}}$ is low (i.e. the instrument is busy)

$\overline{\text{BDA}}$ is low (i.e. bin data is valid)

All $\overline{\text{BIN}}$ lines are unchanged.

The $\overline{\text{BUSY}}$ line goes low to acknowledge the trigger and also to indicate that the component between its terminals is in the process of being measured and should not be removed until the $\overline{\text{BUSY}}$ line goes high again, when the instrument enters the next state.

(4) Not Busy

In this state:

$\overline{\text{BUSY}}$ is high (i.e. the instrument is not busy)

Note that under certain conditions, such as when the instrument is in HOLD and the components under test generate overloads, the turn-around of components being measured and sorted can reach 2Ø per second. If the external hardware cannot cope with this, then the next trigger should be held off until the hardware is ready.

If the external trigger is to be used under GPIB control, then local trigger must be enabled by sending the command "LTON".

5 HARDWARE DETAILS

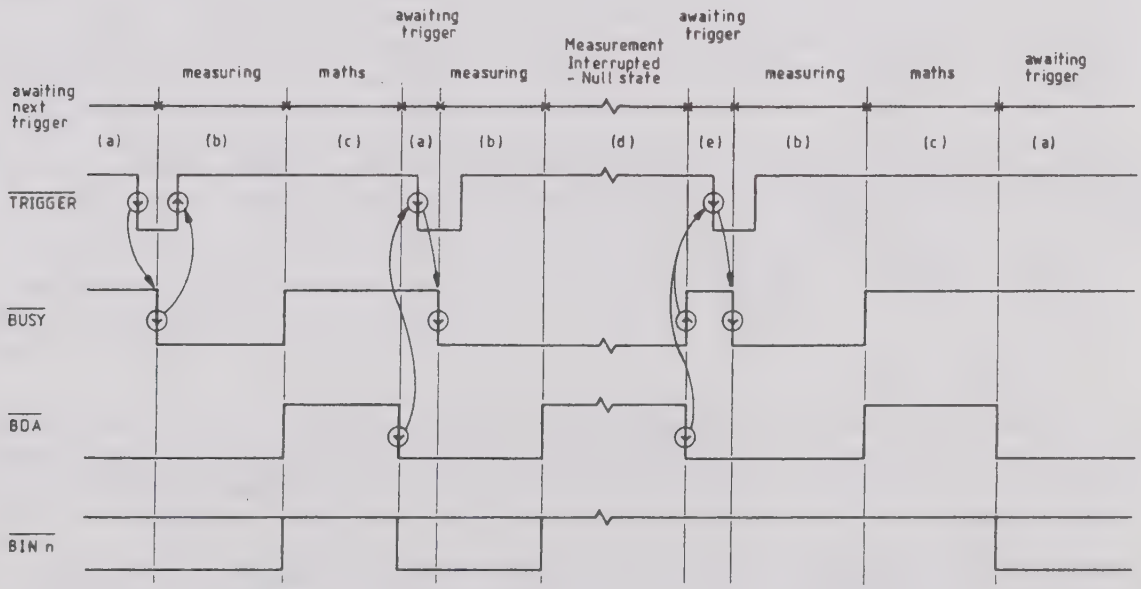
Output drive levels:

Low state : < Ø.5V at 48mA

High state : $\overline{\text{BIN Ø}}$ to $\overline{\text{BIN 7}}$ 2.4V at - 5.2mA

Other outputs, open collector.

Outputs may be used to drive external relays for isolation purposes. In this case an external relay supply not exceeding 5.ØV is required, and the relay coils must be fitted with suitable shunt diodes to absorb back emf energy.



(a) - Awaiting trigger. Previous results available.

(b) - Trigger received - enter busy state. Reset trigger.

(c) - Measurement done - Remove component.

(d) - Measurement interrupted - enter 'null' state.

(e) - Null conditions have been removed - re-enter (a).

Figure E1 Standard Bin Handler Timing

$\overline{BDA}$ is high (i.e. bin data is not valid)

All $\overline{BIN}$ lines high (i.e. no bins selected).

In this state the instrument has finished with the component under test, which may be removed and replaced by the next component. However, the instrument has still to sort the component into the relevant bin and, as the current bin is being updated, all the $\overline{BIN}$ lines are made invalid.

If this process has been completed without interruption, the instrument will re-enter the "Ready for trigger" state, waiting to measure the next component. This sequence will only be interrupted if a key on the front panel of the instrument is pressed or a command is received from a GPIB controller. In this case the current state will be "frozen" until the command has been completed. If the command results in the operating conditions of the Interface being disturbed, the instrument will enter the null state.

When the instrument is ready to continue with the next measurement, it will re-enter the "waiting for trigger" state and the measurement that was aborted may be repeated from the start.

Similarly, after the conditions leading to the null state have been rectified, another measurement may be attempted. For this to be transparent to the bin handler hardware it is recommended that it responds to the negative-going edges of the $\overline{BDA}$ line and the relevant $\overline{BIN}$ line, which will occur only when a component has been successfully measured and sorted. Note that if the component is removed, after the $\overline{BUSY}$ line goes true, and is replaced by another, then the second component will be re-measured and the first will be lost. For reliable results it is recommended that components are removed only when the instrument has completely finished sorting and has re-entered the "awaiting trigger" state. Removing the component upon $\overline{BUSY}$ going high should only be used for maximum speed, when the bin handling mechanism should be disabled before the operation of the instrument is disturbed.

Note that only 8 $\overline{BIN}$ lines are available, although 1Ø are provided in the software. Results indicated in bins 7, 8, and 9, will all make the $\overline{BIN\ 7}$ line go low.

4 EXTERNAL TRIGGER

Measurements may be triggered by pulling the $\overline{TRIGGER}$ line low but ONLY while the instrument is in the "awaiting trigger" state. If the $\overline{TRIGGER}$ line is pulled permanently low the $\overline{BDA}$ line will also be pulled low, impeding its operation.

If continuous measurements are required, a circuit such as that shown in figure E2 may be used to trigger a measurement from the completion of the last binning operation.

Note that the $\overline{TRIGGER}$ line is scanned by the instrument only while in the "awaiting trigger" state and, unlike the front panel key, pulling it low at any other time will not abort a mesurement and re-start another.

Appendix F

Analog Output Option

1 INTRODUCTION

The Analog Output option provides two analog output voltages which vary from Ø to 1 volt d.c. in proportion to the major and minor terms, respectively (upper and lower displayed results). These outputs can be used with a chart recorder to provide a printed copy of the variation in measured parameters with time.

The analog output voltage is calculated according to the measured result and two limits: a maximum limit corresponding to an output of 1V d.c. These limits can be specified by the user according to the scale required. They are specified without dimensions because the analog voltage will be based upon the numerical displayed result, irrespective of its units. Therefore a maximum limit of 1Ø may be interpreted as 1Ø Henrys, 1Ø ohms or 1Ø Farads in Normal mode, or 1Ø% in Deviation and Limits mode.

2 OPERATION

To enable the maximum and minimum limits to be entered, a mode called "Analog Set" is provided. If an Analog Output option card is fitted in the instrument, then "Analog Set" will be displayed in the main index and may be selected by pressing the corresponding soft-key. If the card is missing, then this key will not be labelled. Sample displays from Analog Set are given in figure F1.

When the maximum and minimum limits have been entered, the user may switch the Analog Output to 'ON'. A measurement mode, for example "Limits", may then be entered via the main index. After each successive measurement, the analog voltage will be up-dated. If the result is greater than the maximum or less than the minimum, then the limiting value will be output instead.

The Analog Output will remain on until:

i) It is switched off from Analog Set mode.

ii) The Local button is pressed while in Local mode, giving this button the additional function of an "Analog Off" control.

While the Analog Output is turned off, the output voltage for each channel can be set by the user to "Min" (ØV), "Mid" (Ø.5V) or "Max" (1.ØV) to enable the deflection of the recorder to be set up.

Calculating the appropriate analog voltage slows the overall measurement rate; no such calculation will be made if the Analog Output is turned OFF.

TABLE E1 Standard Handler Interface Signal Definitions

Pin No.	Name	Function
8	$\overline{\text{TRIGGER}}$	External trigger input. Pulling this line low while $\overline{\text{BDA}}$ is low and $\overline{\text{BUSY}}$ is high will cause the instrument to start a measurement.
1Ø	$\overline{\text{BUSY}}$	Output signal. When low, the component at the measurement terminals of the instrument is being measured and should not be removed.
5	$\overline{\text{BDA}}$	Bin Data Available. Going low indicates the completion of a measurement cycle and that the data on the $\overline{\text{BIN}}$ lines is valid.
1	$\overline{\text{BIN Ø}}$	Going low indicates a result in bin Ø
2	$\overline{\text{BIN 1}}$	" " " " " " " 1
3	$\overline{\text{BIN 2}}$	" " " " " " " 2
4	$\overline{\text{BIN 3}}$	" " " " " " " 3
13	$\overline{\text{BIN 4}}$	" " " " " " " 4
14	$\overline{\text{BIN 5}}$	" " " " " " " 5
15	$\overline{\text{BIN 6}}$	" " " " " " " 6
16	$\overline{\text{BIN 7}}$	Going low indicates a result in either bin 7, 8 or 9.
24	GND	Electrical Ground.

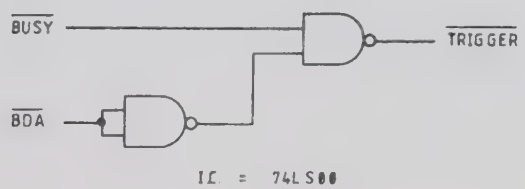


Figure E2 Circuit to generate Continuous Trigger

TABLE F1 ANALOG SET MODE COMMANDS

SOFT KEY LABEL	FULL GPIB COMMAND	GPIB ABBREVIATION	FUNCTION
ANALOG ON/OFF	ANALOG ON *	ANN *	Enable the Analog Option.
	ANALOG OFF *	ANF *	Disable the Analog Option.
OFF LEVEL MIN/MID/MAX	UPPER OFF MIN	UFN	Specify output level when Analog is disabled for the Upper or lower channel. MIN = ØV, MID = Ø.5V, MAX = 1.ØV
	LOWER OFF MIN	LFN	
	UPPER OFF MID	UFD	
	LOWER OFF MID	LFD	
	UPPER OFF MAX	UFX	
	LOWER OFF MAX	LFX	
SET MIN	UPPER MIN "Value"	UMN "Value"	Specify Minimum Limit for Upper or Lower channel.
	LOWER MIN "Value"	LMN "Value"	
SET MAX	UPPER MAX "Value"	UMX "Value"	Specify Maximum Limit for Upper or Lower channel.
	LOWER MAX "Value"	UML "Value"	

* NOTE:
These are the only GPIB Commands that may be used in modes other than Analog Set.

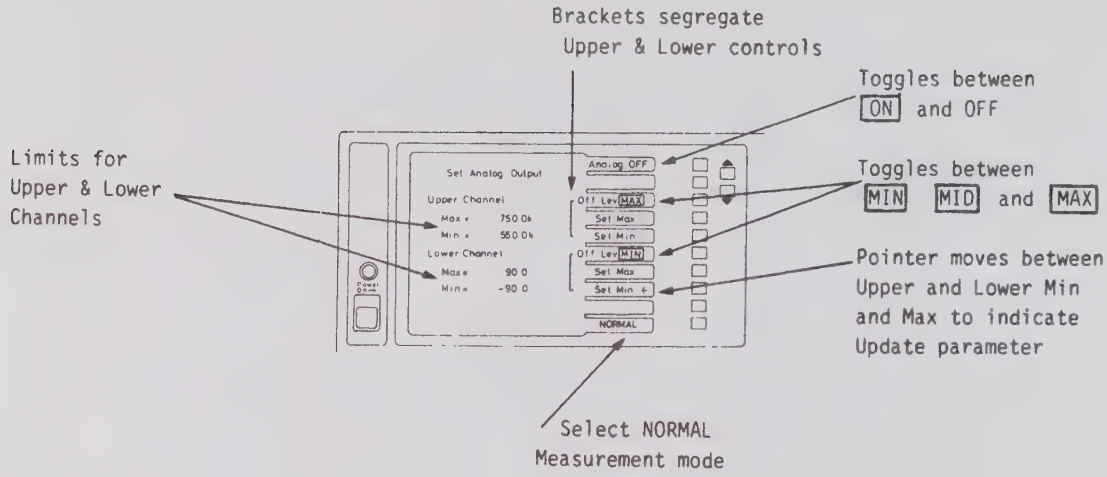


Figure F1 Analog Set Mode Display

New Safety Features (See also page 1:6)

Analyzers with software revision numbered 7.Ø (to check, use CODE Ø.5 - see page 7:4) have two additional safety features, Safety Interlock and Bias Status, applicable to the control of internal bias and (via 3220) external bias. Both these new features require an Analog Output board (AOP) to be fitted in order to use the digital I/O lines available. If an Analog Output board is not fitted, operation of the 3245 will be as for previous revisions.

Safety Interlock - In order to turn the bias on it will be necessary to engage the Safety Interlock. If a switch is connected between pins 5 and 12 of the Analog Output Socket, then the bias can be turned on only if the switch is closed. If the component under test is, for example, an inductor that may generate dangerous back-EMF's due to a change in bias current, then it may be placed in a protective box. Closing the lid on this box will close the switch and so enable the bias current to be applied. Opening the lid will break the switch, causing the current to be turned off automatically and the SAFETY INTERLOCK message to be displayed.

Bias Status - Pin 6 of the Analog Output board will reflect the state of the bias current. When the 3245 is first turned on, the bias current will be off and safe so this line will be high. When the bias is turned on, this line will immediately go low, indicating that the bias is UNSAFE. Only then will the 3245 attempt to turn the bias current on. This line will stay low until the bias has been turned off, whether as the result of a command or automatically due to a fault condition. The line will then go high only when the bias current has been turned off. The line does not, therefore, indicate when the current is at its set value but when the bias current is SAFE or turned off.

This line is intended to drive a solenoid or similar device to lock a box, such as referred to above, and so prevent access to a potentially dangerous component.

In summary:

Pin 6 HIGH = SAFE : the bias is off
LOW = UNSAFE : current may be flowing

3 SOCKET DETAILS

15 pin D-type Female.

Pin 1	Analog	ØV	
Pin 2	Analog	Upper Output ('Major' term)	
Pin 3	Analog	Lower Output ('Minor' term)	
Pin 4	Digital	ØV	
Pin 5	Digital	O/P bit Ø	
Pin 6	Digital	O/P bit 1	
Pin 7	Digital	O/P bit 2	
Pin 8	Digital	O/P bit 3	
Pin 9	Digital	ØV	Reserved for future use
Pin 1Ø	Digital	ØV	
Pin 11	Digital	ØV	
Pin 12	Digital	I/P bit Ø	
Pin 13	Digital	I/P bit 1	
Pin 14	Digital	I/P bit 2	
Pin 15	Digital	I/P bit 3	

4 HARDWARE DETAILS

The Analog Option card is slotted into one of the expansion ports in the rear of the instrument.

5 ANALOG OUTPUT

i) Output Voltage : Ø to 1V d.c. into 1 kohm minimum load. Offset adjustable by internal preset.

Output Resolution : Ø.2%

Step Response : 35 ms from end of measurement to 1% final value.

Protection : Continuous short circuit.

ii) The Analog Output voltage will be calculated according to the following expression:

$$\text{Analog Voltage} = \frac{\text{Measured Value - Minimum Limit}}{\text{Maximum Limit - Minimum Limit}}$$

iii) Maximum and Minimum limits may be entered, with a sign, to enable negative percentage deviation, angles etc to be output.

The maximum and minimum limits will be interchanged automatically if the minimum limit is greater than the maximum limit. If the limits are equal, the output voltage will be ØV if the measurement is lower than the limits, and 1V if greater.

iv) The upper channel output always corresponds to the upper (major term) displayed result, and similarly for the lower channel. In measurement modes with one displayed result, the upper channel only will operate.

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PART 2

3245B INDUCTANCE ANALYZER

PART 2

SERVICE/MAINTENANCE MANUAL

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1 INTRODUCTION

This Manual provides maintenance information on Inductance Analyzer 3240, Precision Inductance Analyzer 3245, its associated instrument - 20A Bias Unit 3220A/1 - and circuit descriptions of the four plug-in options available for the 3245: RS232-C, GPIB Interface, Standard Handler Interface and Analog Output. Separate handbooks provide operating instructions: TP227 for 3240, TP211 for 3245 and the plug-in options, TP219 for 3220, and TP223 for 3220A.

The 3240, 3245 and 3220A/1 are sophisticated instruments and their internal circuits should not be adjusted except by suitably qualified personnel with access to the test equipment and Standard components specified.

WARNING

> Very high voltages are generated in inductive circuits if the path is broken while a heavy current is flowing. The energy stored is proportional to the square of the current: back emf's can reach many kilovolts. NEVER touch such circuits while the direct current is flowing.

---

2 SYSTEM DESCRIPTION (3240 & 3245)

2.1 MICROPROCESSOR CONTROL

All functions of the system are under the direct control of a microprocessor (MPU). Each automatic cycle of operations includes an interrogation of the keypad selections - the keys do not operate directly on the measurement circuits. The MPU then controls these circuits to obtain comparative voltages for the Unknown and Standard impedances under the selected test conditions. By resolving these voltages into orthogonal components, and subsequent computation, the selected type of readout information is used to update the CRT display.

The MPU polls the keyboard (and GPIB - IEEE) as a background task. When any change is detected, the measurement is aborted and the input instruction serviced. If an ac measurement is required, it runs through a sequence of 6, 8 or 12 operations (according to the type of measurement and the Speed selected: only 4 operations for a dc measurement). The operations involve the selection of the Standard and Unknown voltages and the appropriate reference signal for a phase-sensitive detector (psd). The MPU also selects the integration time used for A-D conversion. On completion of the sequence, the selected parameters are computed, trim corrections applied, and the display updated. Write to the display occurs only when changes are needed, and then only to those areas needing update. Further details are in section 2.3 and in the section 'Screen Display Character Generation'(2.6).

2.2 BASIC MEASUREMENT

Refer to Fig 2.1. The guard amplifier produces a feedback current through the Standard resistor, Rs, exactly matching the current through the component under test, Zu. A single measurement channel is switched electronically to measure the corresponding two voltages produced, Es and Eu. Resolution of these into in-phase and quadrature components, and subsequent computations, provides the required information for the display.

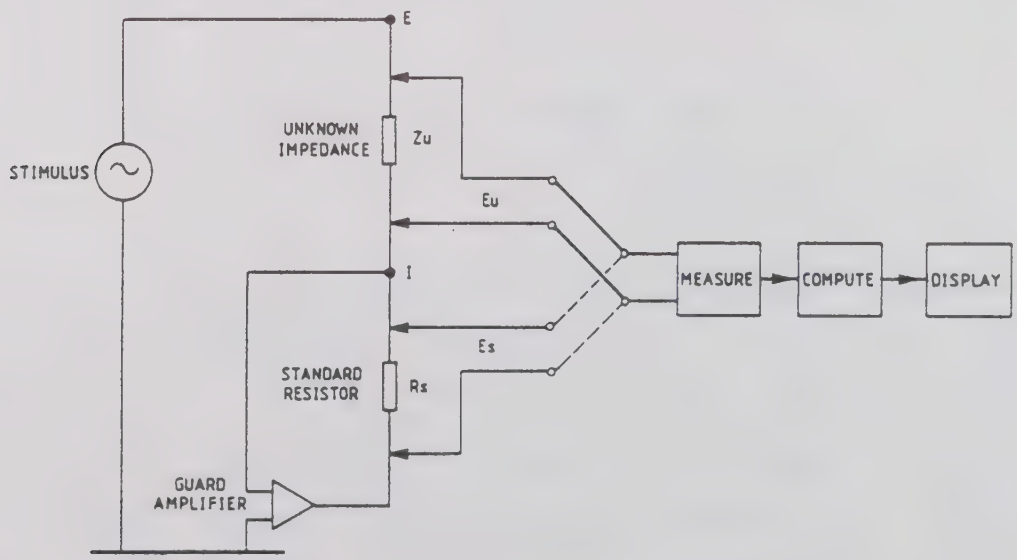


Fig 2.1 Basic Measurement

2.3 MEASUREMENT SEQUENCE

On voltage-drive ranges (3-7), the current-derived signal Es is measured first, followed by the Unknown voltage Eu. This order is reversed on current-drive ranges (1 & 2).

In the measurement channel, the psd resolves the signal to be measured, with respect to a reference signal of the same frequency as the drive signal. The orthogonal outputs of the psd are fed to the A-D converter.

The psd reference signal has four phase settings (0 - 3) separated by precise 90°shifts. Their phase relationship to the drive signal is, however, arbitrary.
The sequence for ac measurements on ranges 3-7, at NORMAL or FAST speeds, is:

Select Es
Settling delay (frequency-dependent)
Measure with psd phase 2
" " " " 0
" " " " 1
" " " " 3
Select Eu
Settling delay
Measure with psd phase 3
" " " " 0
Compute results
Output to display/output option

On repetitive measurements, Es is selected after the sixth measurement and the results computed and output during the subsequent Es settling delay.
The polling sequence checks whether each A/D conversion is complete.

If an overload occurs at any point, the sequence is aborted and auto-ranging started. With Hold selected, the sequence continuously restarts and RANGE ERROR is reported.
On SLOW speed, both Es and Eu are measured at all four psd phases (ie 8 measurements).
For Rdc measurements, a chopper converts the dc voltage to ac. Measurements are then made using only phases 0 and 2 with the psd (a total of 3 measurements on NORMAL or FAST, 4 on SLOW).

On transformer measurements, separate connections are made to the primary and secondary windings. The primary voltage is Ep and the derived signal from the primary current is Es (ie the Standard voltage); the secondary voltage becomes Eu. Each of these is measured at all four psd phases (12 measurements in all, on all three speeds).

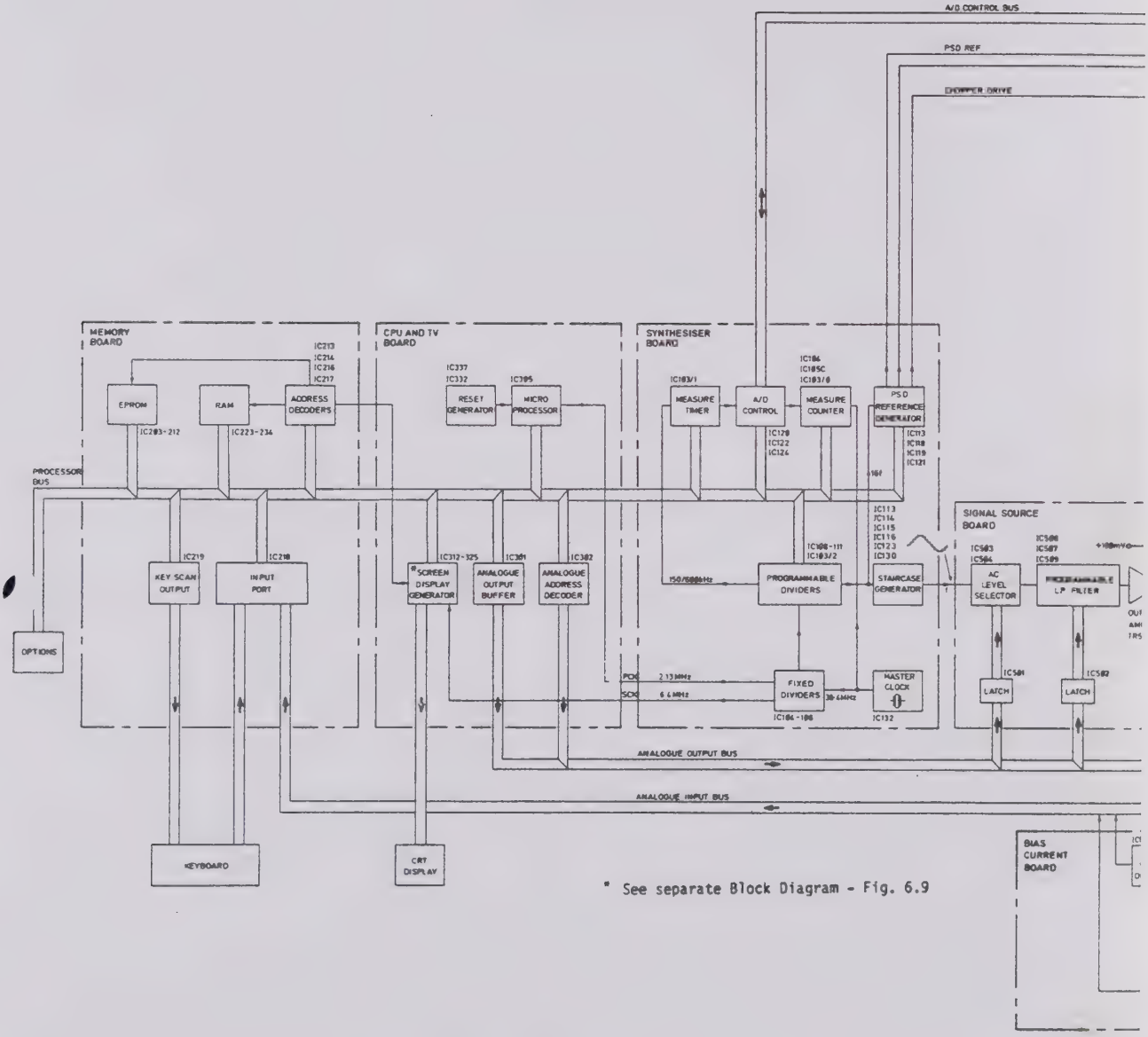
2.4 OVERALL SYSTEM

Refer to the Block Diagram, Fig. 2.2, which shows seven circuit boards:

Memory
CPU & TV
Synthesiser
Signal Source
Bias Current
Bridge
Detector

Not shown on Fig. 2.2 are the Mother board (into which the above are fitted), the power supply sub-chassis nor any of the optional plug-in boards available for the 3245. Because circuit functions are interdependent (one board serving more than one purpose) the descriptions are given under the following headings:

Digital System	Section	2.5
Screen Display Character Generation		2.6
Fixed Dividers		2.7
Programmable Dividers		2.8
Staircase Generator		2.9
Chopper Drive Circuit		2.10
AC Level Selector		2.11
Programmable Filter		2.12
Output Amplifier		2.13
Signal Source Selector		2.14
Source Resistance Selection		2.15
Bridge		2.16
Neutralizer		2.17
Range Selection		2.18
Gain Selection		2.19
Programmable Filter		2.20
Overload Detector		2.21



* See separate Block Diagram - Fig. 6.9

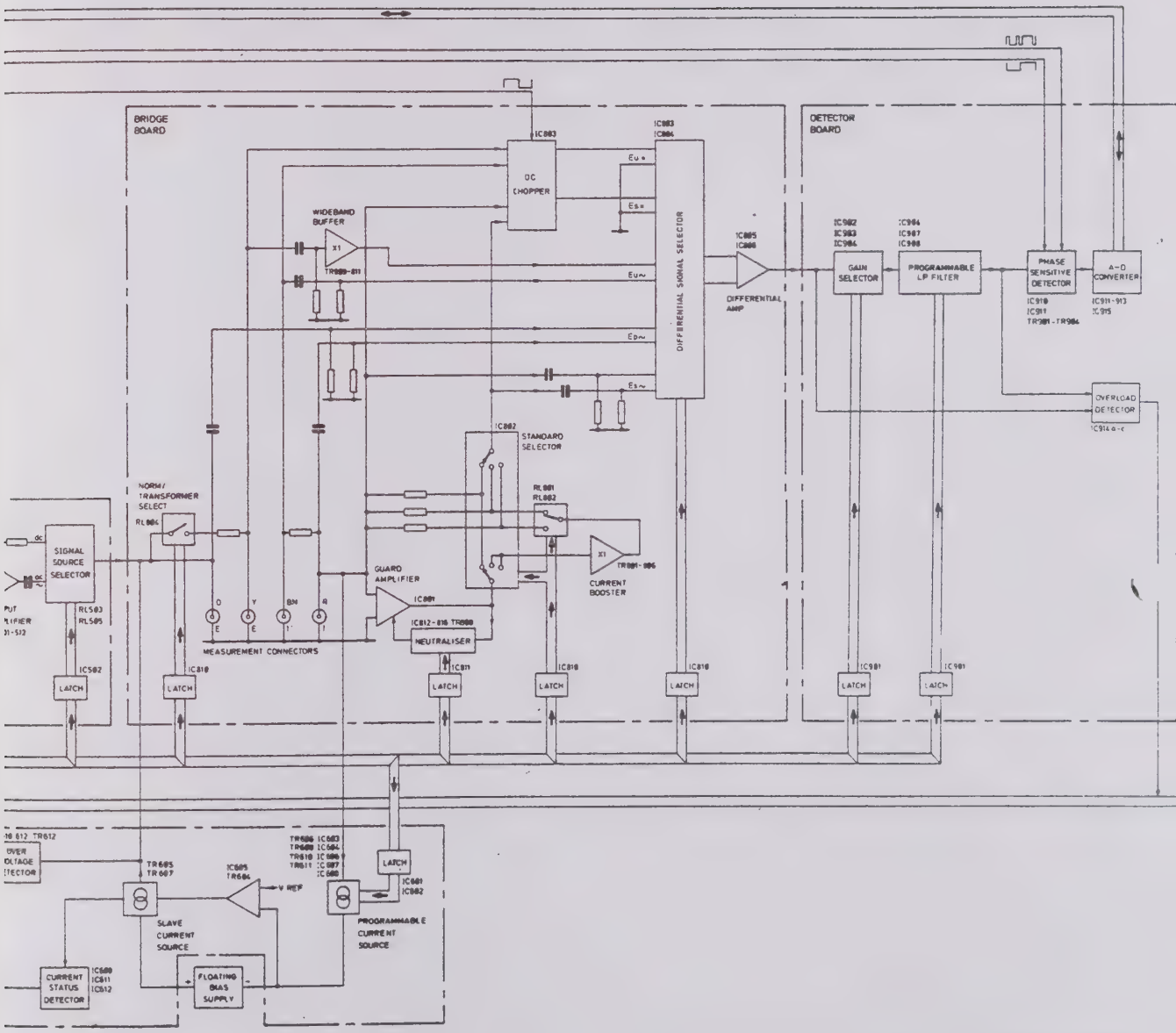


Fig. 2.2 Block Diagram

	Section
PSD, & PSD Reference Generator	2.22
A-D Conversion	2.23
Measure Counter	2.24
Measure Timer	2.25
A-D Conversion Timing	2.26
Internal Bias	2.27
Programmable Current Source	2.28
Slave Current Source	2.29
Current Ready Detector	2.30
Overvoltage Detector	2.31
RS232C Option*	2.32
GPIB/SHI Option*	2.33
Analog Output Option*	2.34
Power Supplies/Grounding	2.35

Locations of the circuit elements referred to in these texts are stated, frequently, by board names. Component reference numbers themselves, however, are a general guide to their location:

Prefix	0	Chassis
	1	Synthesiser (Mk I and Mk II)
	2	Memory (Mk I and Mk II) (Also RS232C*)
	3	CPU & TV
	4	Keyboard
	5	Signal Source
	6	Internal Bias
	7	Power Supplies
	8	Bridge
	9	Detector
	10	Mother board
	12-16	(See 3220A/1 section)
	17	GPIB & SHI Option *
	18	Analog Output Option *

* Not applicable to 3240

2.5 DIGITAL SYSTEM CIRCUIT DESCRIPTION

Block Diagram - Fig. 2.2.
CPU & TV Circuit Diagram - Fig. 6.2.
Memory Board Circuit Diagrams - Figs. 6.4 & 6.6.
Keyboard Circuit Diagram - Fig. 6.8

The digital system is based on a Z80 MPU, (IC305, CPU & TV board), operating with a 2.13MHz clock, which is connected via buffers to a 16-bit address bus and an 8-bit bi-directional data bus. These connect to the memory circuits, the screen display generator, synthesiser and A-D control circuits, and to the external interface option slots.

The Z80 (CPU) has two modes of addressing external devices. These are (a) memory mapping and (b) I/O mapping.

(a) Memory mapping uses the whole of the address bus and hence can address 64k bytes. The address is qualified by the $\overline{\text{MREQ}}$ strobe. A Read ($\overline{\text{RD}}$) or Write ($\overline{\text{WR}}$) function is defined by the appropriate strobe to qualify the data.

(b) I/O mapping uses only half the address bus (AB0-AB7) and hence can only address 256 bytes. The address is qualified by the $\overline{\text{IORQ}}$ strobe. The $\overline{\text{RD}}$ and $\overline{\text{WR}}$ strobes qualify the data as above.

In the 3240 & 3245, the hardware is addressed in both modes, according to its function. Detailed address maps are in section 2.36.

The Eprom address decoder, (IC213/214, Memory board), provides 10 x 4k blocks for 2732 memories (MkI Memory boards) or 4 x 16k blocks for 27128 memories (MkII Memory boards).

A separate 1k block decoder, IC216, is provided for RAM and memory-mapped hardware. The top 1k block is used for hardware and also feeds the page enable line $\overline{\text{ENF}}$ on the option connector. The next 1k block down ($\overline{\text{SEN}}$) is used for the screen circuits (see separate description) with the working RAM below this. The top 1k block is further decoded (IC217) to provide 6 memory-mapped enable lines to the hardware ($\overline{\text{MEN}}$ 0-5).

The top 1k of RAM is non-volatile, using CMOS devices with a 3V Lithium primary cell back-up. At power-up, these devices change over to the internal 5V supply via D204 and D205. TR200, 203, 204 hold off the enable lines to the non-volatile RAM until internal power supplies have been established, and normal microprocessor operation is ensured.

To permit operation of slow hardware blocks, a wait state is generated whenever the hardware or screen is addressed (IC 306, CPU & TV board).

To minimize digital noise pickup, the data and address buses are not routed to the analog measurement areas (signal source, detector, bridge, internal bias unit). Processor inputs from this area (ANI 4-7) feed to a common input port (IC218) located on the Memory board. Processor outputs to the analog area are I/O mapped and are routed via IC301 to a special 'quiet' data bus (ANO 0-7) which is inactive except during an I/O write. Decoded enable lines ($\overline{\text{OEN}}$ 0-7) provide for up to 8 latches to be connected to this bus.

All the above inputs and outputs are at TTL logic levels, level shifting for CMOS gates or heavy-duty relays being provided locally as required.

The keyboard drive has 4 latched addresses and 4 data lines which are decoded into 10 rows x 4 columns. The keys are polled periodically during the measurement sequence at times when any resulting digital noise pickup would be unimportant to measurement accuracy.

Power-on Reset (approx 200ms pulse) is provided by IC332. This can also be triggered during fault-finding by an internal master reset button located on the CPU & TV board. Additionally, IC337 generates a master reset (without delay) whenever the +5V digital supply falls below 4.75V, which helps to maintain the data integrity of the non-volatile RAM under supply drop-out conditions.

2.6 SCREEN DISPLAY CHARACTER GENERATION

Screen Display Generator Block Diagram - Fig. 6.9.
CPU & TV Circuit Diagram - Fig. 6.2.

The screen display circuits, located on the CPU & TV board, generate separate horizontal sync, vertical sync and video signals, all at TTL levels, which are routed to the CRT drive circuits.
A non-interlaced horizontal raster is used, with a line frequency of 16.0kHz and frame frequency of 54.98Hz.

The microprocessor addresses the screen as 21 rows of 38 adjacent character cells, although the display area is only 19 rows of 37 characters.
Each character cell is 8 dots wide x 12 lines high. A single byte describing the content of each character cell is stored in each of 798 (21 x 38) screen RAM locations (IC317, 318). From these, any one of 256 standard characters can be selected for display in each character cell.
The character PROMS (IC324, IC325) contain the patterns of light and dark dots making up each character, and each location in either PROM stores one horizontal line of information. Address lines A0 to A3 select the 12 lines forming each character, while address lines A4 to A11 select from the 256 different characters.

Each of the two PROMS contains a different character set, one or the other being selected by IC321.

The display is generated by sequentially scanning the address lines of the screen RAM and the character PROM. The resulting pattern of 8 horizontal dots at a time are loaded into a shift register (IC323) and clocked out to the display by a 6.4MHz dot clock.

Scanning of the address lines, generation of sync pulses and cursor control are all handled by an LSI chip (IC312) which is initialized at power-up by the microprocessor. To avoid interfering with the display, the processor can write to the screen RAM only during line or frame flyback. If it attempts to write at any other times, a wait state is generated by the control logic.

During screen RAM updating, the RAM address lines are switched from IC312 to the processor address bus, by means of data multiplexers IC314-316.

2.7 FIXED DIVIDERS (located on Synthesiser board)

Circuit Diagrams - Figs. 6.11 & 6.13.

The fixed dividers provide the CPU and video clock frequencies by division from the 38.4MHz crystal oscillator IC132. IC104b and IC106 form ÷2 and ÷3 stages respectively to produce the 6.4MHz screen clock SCK. A further division by 3 (IC105b and IC107c) provides the 2.133MHz processor clock PCK.

2.8 PROGRAMMABLE DIVIDERS (located on Synthesiser board)

The 42 drive frequencies (20Hz to 300kHz) are initially generated at 16fo (ie 320Hz to 4.8MHz). Frequencies from 1.6MHz (=16 x 100kHz) upwards are generated directly by the dividers IC108 and IC109a, the required output frequency being selected by data multiplexer IC110.

Frequencies below 1.6MHz are provided by counter 2 of the programmable triple timer counter IC103, using as its clock the selected output frequency from IC110. IC111 forms a 2-way switch, selecting either the direct or divided 16fo signal for further processing by the STAIRCASE Generator.

2.9 STAIRCASE GENERATOR (located on Synthesiser board)

The 16fo clock is used to generate an eight level, 16 time sample approximate sinewave by analog summing of the output of the bidirectional shift register IC114. The register is arranged to generate a cyclic bit pattern of increasing logic ones followed by decreasing logic ones. The summing amplifier IC130 has weighted inputs to give the required approximate sine amplitude at S1 for each time sample generated by the register.

Control counter IC113 provides a binary code for each time sample. At count 0 the register is loaded with 1000 0000 with S0, S1 held at logic one. At the 9th time sample the register direction is reversed, and on reaching the 15th sample the register is re-loaded. IC115 with IC116 decodes the 0, 9th and 15th time samples for shift left/right control of the register via latch IC123a.

2.10 CHOPPER DRIVE (located on Synthesiser board)

The control counter IC113 also provides a square-wave output at the measure frequency which, when enabled by the processor via IC115, provides the bridge chopper drive for dc resistance measurement.

2.11 AC LEVEL SELECTOR (Signal Source board)

Circuit Diagram - Fig. 6.15.

The stepped ac drive signal (at TP03) is received by the multiplying DAC IC503 which, with the range amplifier IC505a, sets the ac level between 10mV and 5V. The preset R506 adjusts the maximum drive level (set at 1.2kHz).

The processor control signals are received via the quiet analog bus at the octal latch IC501. Bits 0 to 5 set the signal over a 50-step range. Bits 6 and 7 set the range amplifier accordingly to give:

AC Level Range	IC501 pin number 12	9	Range Amp Gain
0 to 500mV	1	1	x1
520mV to 1V	0	1	x2
1.05 to 2.5V	1	0	x5
2.6 to 5.0V	0	0	x10

2.12 PROGRAMMABLE FILTER (Signal Source board)

IC506 & IC507 form a state variable low-pass filter which provides initial filtering of the drive signal at the output IC507b (TP04). Additional filtering is provided by a similar filter in the detector circuit.

The corner frequencies are adjusted from the processor by selecting the required integrator C & R values via the analog multiplexers IC509a & b and the reed relays RL501 & RL502. The settings for the Signal Source filter (which are interleaved with the Detector Filter settings) are as follows:

Frequency Range	IC 502 pin number			
	6	9	15	12
20Hz	0	1	1	1
25 - 50Hz	0	1	1	0
60 - 120Hz	0	1	0	1
150 - 300Hz	0	1	0	0
400 - 800Hz	1	0	1	1
1kHz - 2kHz	1	0	1	0
2.5 - 5kHz	1	0	0	1
6 - 12kHz	1	0	0	0
15 - 30kHz	1	1	1	1
40 - 75kHz	1	1	1	0
100 - 300kHz	1	1	0	1

2.13 OUTPUT AMPLIFIER (Signal Source board)

TR501 through to TR512 form a conventional audio power amplifier with a nominal gain of 2.5 times. TR505, 510 provide constant-current limit protection at nominally 380mA while D512, D513 clamp excessive transient voltages accidentally fed into the E terminal of the bridge to within the supply rail limits of the amplifier. The ac output is coupled to the Bridge circuits via the capacitor bank C24 to C28, to permit application of dc bias at the E terminal. The power amplifier output is biased to -0.5V nominal to polarize these capacitors in the absence of bias.

2.14 SIGNAL SOURCE SELECTOR

RL505/1 selects ac or dc drive, the dc drive of 100mV being derived from the divider chain R562, R563, R564. At power-up, RL505 is de-energized with Rdc mode selected. The ac-coupled amplifier output rapidly settles with R560 (1R8) bleed resistor selected.

2.15 SOURCE RESISTANCE SELECTION

Relay RL503 and associated driver circuit TR513 TR514 selects 2Ω/50Ω source resistance depending on the range requirements selected by the processor auto-range routine. The 2Ω resistor is located on the Bridge board and is increased to 50Ω by switching R558/559 in series on the Signal Source board.

The truth table for these functions is as follows:

Range No (See 2.18)	Source R	IC502 pin number 19	5	16
1 - 2	50Ω	0	1	X
3 - 5	2Ω	1	1	X
6 - 7	50Ω	0	1	X
Bias OFF	-	X	1	0
Bias ON	-	X	1	1
Rdc (Normal)	55Ω	0	0	0
Rdc (Low)	7Ω	1	0	0

2.16 BRIDGE CIRCUIT

Circuit Diagram - Fig. 6.17.

Components to be measured are connected between the E (signal source) and I (current sense) terminals. The action of the virtual-ground guard amplifier IC801 forces the current at the I terminal to flow through one of three standard resistors (R822 to R824), selected according to measurement range by IC802, RL801, RL802. TR801 to TR806 form an output current booster used with the 10-ohm and 640-ohm Standards. This circuit incorporates simple constant-current overload protection (D809 to D812 with R847, R848). D801 to D804 protect the guard amplifier against normal input overloads. Additional protection is provided by FS801 mounted on the Bridge board; this will not normally blow except under exceptional fault conditions.

IC805 and IC806 form a differential amplifier feeding the ac detector circuits. To perform ac impedance measurements, the amplifier input is alternately connected (via IC804) to measure the voltages across the Unknown component (Eu) or the Standard resistor (Es). For each connection, a series of two or four complex measurements is made (see section 2.3), the microprocessor computing the required measurement parameter from the results. The amplifier output appears at TP01 on the Detector board.

TR809 to TR811 form a wideband buffer to isolate the switching action of IC804 from the measurement leads. TR811 is a bootstrap follower driving both the collector of TR809 and its bias divider, maintaining a high input impedance at all frequencies. The output of this buffer feeds an hf phase

trim circuit comprising R810, R811 and the input capacitance of the signal selector/amplifier combination. The resulting phase shift is adjusted on test to balance that due to the stability capacitors (C816, 817, 818, 844) connected across each Standard resistor.

DC blocking is provided for each ac signal input, the input time constants being kept equal. As a result, low-frequency phase errors cancel out when the impedance calculations are performed.

For transformer ratio measurements, the primary winding is connected across the E and I terminals, with the secondary connected across the Eu sense terminals (E' and I'). For this purpose, E' and E are electrically isolated by opening RL804, and the measurement sequence includes an additional measurement of primary voltage (Ep) selected by IC804. As high phase accuracy is unimportant in this case, no buffer or phase trim network is used for Ep.

When making dc resistance measurements, the circuit operation is similar, using a fixed 100mV dc source in place of the ac signal. The dc voltages Eu and Es are routed to the dual differential chopper IC803 where they are converted to 300Hz square-wave signals (360Hz for 60Hz supply settings). These ac signals are selected alternately by the third section of IC803 and then pass via IC804 to the normal ac measurement circuits. TR812 and TR813 isolate the chopper inputs from the bridge circuits during ac measurements, and some input filtering (R815, R816, C805 & C806) is included to improve rejection of supply frequency harmonics.

The truth table for the signal select control lines is as follows (all settings apply with 1V or 100mA signal levels selected):

Function and Range	Signal Select	Standard Resistor	IC810 Pin Numbers 19	5	16	6	15	9
ac range 1-4	Es	10Ω	1	1	0	1	1	0
ac range 5-6	Es	640Ω	0	1	0	1	1	0
ac range 7	Es	5k12	1	0	0	1	1	0
ac	Eu	x	x	x	1	1	1	0
transformer	Ep	x	x	x	1	0	1	1
Rdc (Low)	Es	10Ω	1	1	0	0	0	0
Rdc (Normal)	Es	640Ω	0	1	0	0	0	0
Rdc	Eu	x	x	x	0	0	1	0

2.17 NEUTRALIZER CIRCUIT (part of Bridge board)

For operation at high frequencies (3kHz to 300kHz) the loop gain of the guard amplifier is increased by the action of the neutralizer circuit (IC812 to IC816). Without this circuit, the loop gain is progressively reduced by the current flowing in the compensation capacitor C821. The voltage feeding this capacitor (IC801 pin 8) is scaled by the resistor chain R830-R837, inverted by the video amplifier IC813 (nominal gain -5), further scaled by resistor chain R856 to R860 and integrated by IC816, which is connected in feedforward mode to minimize hf phase errors. The resulting output voltage is applied to either R827 or R828, producing a current which cancels that flowing in C821 at the chosen operating frequency only. For each frequency-setting the scaling attenuators are altered by the MPU to maintain this cancellation. The preset control R874 compensates for the tolerances in C821, C834 and the gain of IC813. The control truth table for the neutralizer circuit is as follows:

Freq (kHz)	IC811 pin number				
	2	19	5	16	6
≤2	0	0	0	1	1
2.5/3	0	1	0	0	1
4	0	0	0	0	1
5	1	0	0	0	1
6	1	1	0	0	1
8	0	0	1	0	1
10	1	0	1	0	1
12	1	1	1	0	1
15	0	1	1	1	1
20	0	0	1	1	1
25	1	0	1	1	1
30	1	1	1	1	1
40	0	0	0	0	0
50	1	0	0	0	0
60	0	1	1	0	0
75	0	0	1	0	0
100	1	0	1	0	0
120	1	1	1	0	0
150	0	1	1	1	0
200	0	0	1	1	0
300	1	1	1	1	0

2.18 RANGE SELECTION (Bridge board & Detector board)

Bridge Board Circuit Diagram - Fig. 6.17.
Detector Board Circuit Diagram - Fig. 6.19.

Impedance measurement range is selected by choice of Standard resistor together with a precision x8 attenuator located on the Detector board. For ac levels ≧250mV or 25mA, seven ranges are available. Below these levels, the settings are altered to increase the detector input levels, and only 5 ranges are available. For transformer measurements, the settings used correspond to the primary impedance, but different settings may be selected with step-up transformers to avoid detector overloads when measuring the secondary voltage.

For dc resistance measurements, only two measurement ranges are provided. The various settings used are detailed in the table.

RANGE SELECTION

AC MEASUREMENTS			HIGH LEVEL ≧ 250mV/25mA			LOW LEVEL < 250mV/25mA		
Range No.	Impedance Coverage(Ω)	Max Level	Standard Resistor	Es gain	Eu gain	Standard Resistor	Es gain	Eu gain
1	<1.25	100mA	10Ω	x1	x8	-	-	-
2	1.25-10	100mA	10Ω	x1	x1	10Ω	x8	x8
3	10-80	1V	10Ω	x1	x1	10Ω	x8	x8
4	80-640	5V	10Ω	x8	x1	640Ω	x1	x8
5	640-5k12	5V	640Ω	x1	x1	640Ω	x8	x8
6	5k12-41k	5V	640Ω	x8	x1	5k12	x8	x8
7	>41k	5V	5k12	x8	x1	-	-	-
DC MEASUREMENTS								
Low	≦2Ω	100mV/16mA	10Ω	x8	x8			
Normal	≧2Ω	100mV/2mA	640Ω	x1	x8			

2.19 GAIN SELECTION (Detector board - Fig. 6.19)

Amplifiers IC903, IC904a with the analog multiplexers IC902a, b and c form a programmable gain stage by selection of feedback ratio at IC902c and forward attenuation at IC902b and IC902a. The x8 ratio is of high accuracy and is used as part of the range selection routines. The other two sections are used only to compensate for drive level variations. With Range Hold and Range 3 selected from the keyboard the following truth table applies:

Gain Ratio			Signal Level	IC901 pin number		
				19	16	15
x8	x4.5	x2.2	0 - 60mV	0	0	0
x8	x4.5	x1	70 - 140mV	0	0	1
x8	x1	x2.2	150 - 240mV	0	1	0
x1	x4.5	x2.2	250 - 520mV	1	0	0
x1	x4.5	x1	540mV - 1.1V	1	0	1
x1	x1	x2.2	1.12 - 2.35V	1	1	0
x1	x1	x1	2.4 - 5.0V	1	1	1

2.20 PROGRAMMABLE FILTER (Detector board)

Amplifiers IC904b, IC907a and IC907b, with analog multiplexers IC908a and IC908b, form a state variable low-pass filter with corner frequencies interleaved with the Source Programmable Filter (see Source board description). The combination of the two filters maintains effective harmonic filtering at all frequencies. The detector filter settings are:

Frequency Range	IC901 pin number			
	9	6	5	2
20 - 30Hz	0	1	1	0
40 - 80Hz	0	1	0	1
100 - 200Hz	0	1	0	0
250 - 500Hz	1	0	1	1
600 - 1200Hz	1	0	1	0
1.5 - 3kHz	1	0	0	1
4 - 8kHz	1	0	0	0
10 - 20kHz	1	1	1	1
25 - 50kHz	1	1	1	0
60 - 120kHz	1	1	0	1
150 - 300kHz	1	1	0	0

The detector filter output appears at TP02 on the Detector board.

Any dc present at the filter output is removed by the selectable ac coupling. The shorter time-constant is selected for faster settling time, when the measurement frequency is 250Hz or above, via junction FET TR905.

2.21 OVERLOAD DETECTOR (Detector board)

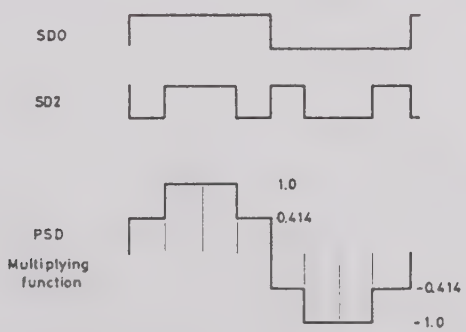
The overload detector monitors the peak signal entering the Detector circuit (5V rms max) and the level at the PSD input (1V rms max) by comparators IC914a and b respectively. If an overload occurs, the output is latched (IC914c).

The measurement cycle comprises 6, 8 or 12 A-D conversions and, at the end of each, the processor reads the latch before setting $\overline{\text{MSR}}$ high, which resets the latch. If an overload has occurred during the previous A-D conversion, the processor will abort the measurement cycle and immediately enter the auto-range routine.

2.22 PSD, & PSD REFERENCE GENERATOR (Detector & Synthesiser boards)

Detector Circuit Diagram - Fig. 6.19.
Synthesiser Circuit Diagrams - Figs. 6.11 & 6.13.

The phase-sensitive detector (PSD) employs a 4-level multiplying reference signal which contains no harmonics below the seventh. Hence the PSD rejects low-order odd harmonics as well as all even harmonics. The reference signal is made up from the sum of two waveforms SD0 and SD2:

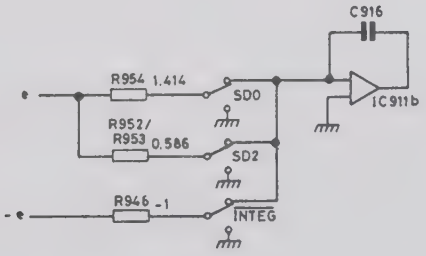


SDO and SD2 can be generated in 4 different phase positions and are derived from clock signals of 16, 4 and 2x the measure frequency fo by the gating circuits IC118 and IC119. The gated waveforms are synchronized with the Staircase Generator at the output latches IC121 a and b to remove propagation delay variations. The PSD drive waveforms are enabled only during the integration period of each A-D conversion.

The processor selects the appropriate phase position via control lines PP0 and PP1 according to the following table:

Octal Latch IC102 Output			
PP1 P2	PP0 P19	Phase	
0	0	0°	0
0	1	90°	1
1	0	180°	2
1	1	270°	3

The PSD drive signals are received at the PSD (located on the Detector board) via buffers TR901 - TR903 and drive IC910 which serves as a two-pole change-over analog switch. (SDO and SD2 in diagram).



The signal current to the A-D integrator IC911b is modulated by the selection of R954, R952/R953 or neither.

Dual polarity operation is obtained by biasing the circuit to 50% of fsd during the A-D integration period. This bias is derived from the 5V reference voltage, inverted by IC911a, which also provides a phase-inverted measure signal to the PSD to provide full-wave rather than half-wave detection. The effect of this is to cancel lf noise and to improve suppression of switching transients. The multiplied signal is fed directly into the analog to digital converter integrator as a current, which avoids amplifier slew-rate distortion at the fast switching edges.

2.23 ANALOG TO DIGITAL CONVERSION (Synthesiser and Detector boards)

The A-D converter comprises a digital control section located on the Synthesiser board (component prefix 1) and an analogue section on the Detector board (component prefix 9). Once triggered by the microprocessor, the A-D conversion process proceeds unsupervised, and on completion it waits to be polled by the microprocessor, as part of the keyboard polling routine. Each measurement cycle comprises 6 separate A-D conversions (8 with SLOW speed selected, 12 for transformer measurements), with different signal and/or PSD phase selections. See section 2.3.

The A-D converter uses the charge balancing technique, where the signal is summed with the reference during the integration period. The reference signal is switched on and off as required to maintain the integrator output close to zero. During integration, the integrator output oscillates about zero, the measure counter being enabled whenever the reference signal is on. At the end of the integration period the PSD is switched off and the reference current is left on to take the integrator output to an arbitrary negative level outside the band of oscillation, giving a final accurate conversion count.

2.24 MEASURE COUNTER (Synthesiser circuit)

Synthesiser Circuit Diagrams - Figs. 6.11 & 6.13.

The A-D counter uses a 20-bit measure counter chain. The most significant 16 bits are provided by counter 0 within the programmable triple timer counter IC103. IC105a and IC104a prescale the 16-bit counter to provide the remaining 5 (least significant) bits. The counter chain is clocked directly by the 38.4MHz master clock and enabled by the $\overline{\text{MSR}}$ control line from the processor being active with the INTEGRATION control signal (see 2.26). On a long measurement the counter chain may overflow. This is detected by latch IC123b to inform the processor. The overflow is noted in software and the latch is reset before the next overflow can occur via the $\overline{\text{MEN3}}$ line.

2.25 MEASURE TIMER (Synthesiser circuit)

Synthesiser Circuit Diagrams - Figs. 6.11 & 6.13.

Integration times are set by the user via the Fast, Medium and Slow measure modes. The processor loads counter 1 (in one-shot mode) of the triple timer counter IC103 with the appropriate binary number to give a time out within a whole number of measure periods. When enabled by the RUN control line (from the A-D control circuit) the counter gate IC103 p14, becomes logic high and the counter counts down. On reaching zero count, output 1 (IC103 pin 13) becomes a logic high, resetting the $\overline{\text{INTEG}}$ latch IC120b at the next rising edge of the synchronizing signal.

2.26 A-D CONVERSION TIMING (Synthesiser & Detector boards)

Synthesiser Circuit Diagrams - Figs. 6.11 & 6.13.
Detector Circuit Diagram - Fig. 6.19.

The following description of the A-D conversion process should be read with reference to the timing diagram Fig 2.3.

The MPU initiates a measurement by setting $\overline{\text{MSR}}$ low, which enables the RUN latch IC122b and resets the zero crossing comparator IC913. The RUN latch becomes set on the next measure signal period via the SYNC flip-flop IC122a, which generates a clock waveform at measure frequency in phase with the STAIRCASE GENERATOR. The RUN latch in turn enables the INTEGRATOR latch IC120b which in turn enables the PSD drive latches IC121a and b. The RUN and INTEGRATOR control lines activate the analog switch IC912, setting the A-D converter to measure mode by opening the integrator capacitor shorting switch (IC912, S4, D4). The A-D Offset reference (which is routed through the PSD full-wave inverting stage IC911a, R946) is also enabled at IC912, S1, D2.

The HIGH/LOW monitor compares the integrator output with OV, sending an error status signal (H/L) to the CHARGE BALANCE CONTROL circuit IC109b, IC124, IC120a, IC127. The charge balance control generates two 2.34kHz clocks with duty cycles of 15/16 and 1/16 at IC124 outputs. At the start of each charge balance period, the appropriate waveform is selected by the sampling circuit IC120a, IC127 depending on the status of the H/L line for the predominantly on or off reference current at the A-D converter.

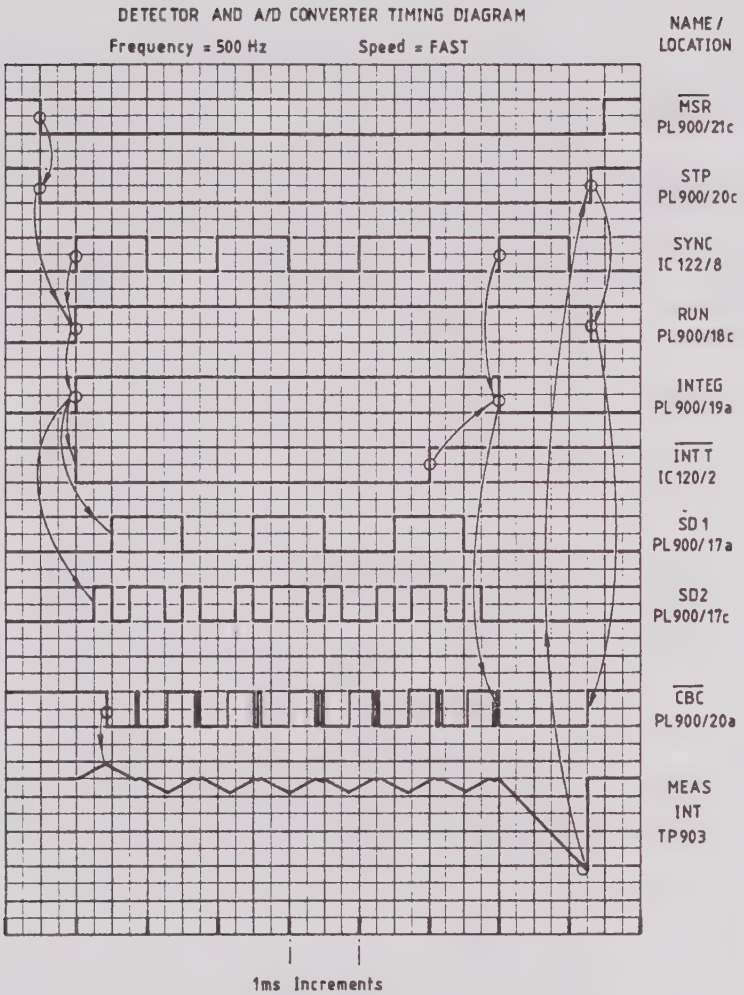


Fig. 2.3 Timing Diagram

On later versions of this circuit (see Fig.6.13) IC135 selects a higher charge balance clock frequency, for measurement frequencies between 600Hz and 1.5kHz, giving improved measurement accuracy.

The CBC and $\overline{\text{CBC}}$ control lines are generated at IC133 latch which is synchronized with the master clock to remove timing errors. The reference current is switched into the integrator summing junction by IC912, S3, D3 via R947.

At the end of the integration time out (generated within the programmable timer counter IC103), the D input at IC120b INTEGRATOR latch becomes high.

The next measure sync period toggles the INTEGRATOR latch, inhibiting further PSD and CBC drive. The $\overline{\text{INTEG}}$ line remains high, holding the reference current switch IC912, S3, D3 on. The integrator output is forced -ve until the zero crossing comparator IC913 latches, sending a STOP signal to reset the RUN latch IC122b, this in turn resetting the INTEGRATOR latch IC120b to switch off the reference current to the integrator. The RUN line becoming low informs the MPU that conversion is complete and $\overline{\text{MSR}}$ is set high to reset the A/D converter. The $\overline{\text{MSR}}$ line may be set high at any time by the MPU if a measurement is to be aborted.

2.27 INTERNAL 1A BIAS (Rear panel)

Block Diagram - Fig. 2.2.

The 1-amp bias circuit consists of two current sources which are connected in series across the unknown impedance for dc bias but are grounded to ac to avoid applying a parallel shunt error to the measure circuit.

The current level is set by the programmable current source under processor control and the slave source follows the demanded current. Because the current sources are powered from a floating supply, no bias current flows into the measure circuits.

Linear operation of the bias circuit is maintained by regulating the voltage across the programmable current source to nominally 4.3V (which in turn defines the voltages across the unknown impedance and slave current source) by a voltage control loop which adjusts the slave output until the two source current levels are equal.

The guard amplifier on the Bridge board effectively references the I terminal (and, hence, the 1A bias circuit) to chassis potential with the FLOATING BIAS SUPPLY -ve held at 4.3V below chassis potential. Note that all voltage designations shown on the circuit diagram are nominal potentials with respect to chassis.

The bias is switched off by inhibiting both source and slave circuits to ensure no current flows into the measure circuit.

2.28 PROGRAMMABLE CURRENT SOURCE (Internal 1A Bias board)

Internal Bias Current Circuit Diagram - Fig. 6.21.

Power transistor TR610 and driver TR611 with series emitter feedback is used for current control. Amplifier IC607 buffers and removes the power transistors Vbe offset to maintain the emitter resistor voltage equal to the programmed reference voltage at the output of IC606a.

The programmed reference voltage circuit is arranged in two multiplier stages. IC606b inverts the +5V from IC regulator IC614 to give -5V across the reference attenuator chain R601 to R603. Analog multiplexer IC603 selects the range multiplier under processor control (see table) for x1, x2 or x5. The multiplying digital to analog converter IC608 provides the fine settings over a 50-step range. (Normal binary weighting.) IC606a transforms the DAC output current into a reference voltage and R622, C602 ensures the current steps are ramped, to minimize transient voltages across the unknown coil. A x10 multiplier setting extends the current range by switching the source control circuit to power transistor TR608 with its 1-ohm emitter resistor via analog multiplexer IC608. The output transistor stages are inhibited by switching the bases to the common -5B line when bias is off.

Truth Table for full setting within each range for internal bias circuit

Range Multipliers				Range	Step Size	Quad Latch				Octal Latch								Output-MUX	
						IC601 Pin no				IC 602 Pin no								IC08 Pin no	
x10	x5	x2	x1			2	7	15	10	(msb)6	15	5	2	16	19		(lsb)	10	9&11
X	X	X	X	BIAS OFF	X	0	0	0	0	0	0	0	0	0	0			1	1
0	0	0	1	50mA	1mA	1	0	0	0									0	1
0	0	1	0	100mA	2mA	1	0	0	1									0	1
0	1	0	0	250mA	5mA	1	0	1	0	1	1	0	0	1	0			0	1
1	1	0	1	500mA	10mA	1	1	0	0									1	0
1	1	1	0	1A	20mA	1	1	0	1									1	0

2.29 SLAVE CURRENT SOURCE (Internal 1A Bias board)

Internal Bias Current Circuit Diagram - Fig. 6.21.

Error amplifier TR604 compares the chassis potential (buffered via IC605) with the 5V reference IC614, which is connected to the -ve rail of the floating supply (-5B). The amplifier error signal at TR604 collector controls the Slave power stage TR605, TR607.

When bias is off, the circuit is inhibited by TR603 which shorts the input to the power stage. R639 provides a bleed which ensures the Slave power stage continues to conduct when the programmed current source is set to very low values. This is switched out when bias is off via TR609.

When the circuits are inhibited, the base-emitter diode of TR604 provides a 4.5V feed to the divider R631, R632 which maintains the voltage across the ac ground capacitor C606/C619. The diode D611 provides rapid charging at power-up to prevent large transient currents when bias is first switched on.

2.30 CURRENT READY DETECTOR

When bias is turned on, or the level changed, the bias current circuit takes time to settle. The rate of change of bias level with time is monitored by the current ready detector which differentiates the voltage at the slave power stage emitter resistor R636 and IC609. After filtering to remove measure signal ripple (R654, R656, C611, C612), the amplified derivative signal (IC611a) is applied to the window comparator IC612. When the current has settled, the current status line ANI4 goes high.

2.31 OVERVOLTAGE DETECTOR

Excessive voltage drops across the Unknown impedance are detected by monitoring the voltage across the slave power stage and comparing this with the reference voltage at D604 anode. If this voltage falls below 3.9V, either continuously or on signal peaks, IC610 output goes -ve and pumps the peak detector circuit TR612 R658 C613, which gives a steady logic low output on the voltage status line ANI5 until the excess dc drop or the ac level is reduced.

2.32 RS232C INTERFACE OPTION (SIO OUTPUT) (N/A to 3240)

Circuit Diagram - Fig. 6.33.

The card address is set up on switches S201 and S202. Gates IC200, IC201, IC203 provide an output when a matching address occurs on the address bus.

The 3245 data bus is connected to the UART IC208 via buffers IC205, IC206. The baud rate and data characteristics are set on switch S203, which is connected to the bus via IC207.

The serial data and control interface with IC208 is via buffers and the two-pole switches of S204. These switches permit the interchange of the data and handshake lines so that the 3245 may operate as the computer or the peripheral end of the RS232C link.

2.33 GPIB/SHI OPTION (N/A to 3240)

GPIB/SHI Option, Circuit Diagram - Fig. 6.23.

IC1708 Decodes the I/O address to produce a high at IC1712 pin 12 when the board is accessed.

When SW1702 is not fitted, the card has a default address range of 10 to 17 Hex. When used as an SHI option, SW1702 is fitted and the address range becomes 30 to 37 Hex.

IC1712 & IC1709 delay the decoded select by one cycle of 'CLOCK' to produce the chip select ($\overline{CS}$) for IC1701.

The data strobe for IC1701 (O2) is produced by gating together read ($\overline{RD}$) and write ($\overline{WR}$) pulses and delaying by one cycle of 'CLOCK'.

On a read from or write to IC1701, the internal registers are selected by RS0 to RS2 and data is coupled to/from the option bus by IC1707. IC1707 is made active by the same signal as $\overline{CS}$, and its direction determined by $\overline{RD}$.

When a read of register 4 of IC1701 is attempted, an enable is produced at $\overline{ASE}$ which in turn enables IC1706 and couples SW1701 to the option bus. By this means the user set Device address and talk only bit are read by the processor.

IC1702 to IC1705 are tristatable drivers which convey signals between the Output port SK1702 and the GPIA IC1701.

IC1701 may be configured under software control to generate an interrupt in response to certain IEEE bus events. The interrupt is sent to the processor by the open collector driver IC1711, its output appearing at pin 8.

At power-up, the microprocessor performs a read at bit 7 of register 3 of IC1701, to establish the presence of a GPIB and/or SHI option in the instrument.

2.34 ANALOG OUTPUT OPTION (N/A to 3240)

Analog Output Option, Circuit Diagram - Fig. 6.25.

The analog output option provides two dc output voltages, derived from two rectangular-wave signals under software control, in addition to four TTL input and four TTL output lines.

IC1801 performs the initial address decoding, the output on pin 6 going high whenever I/O addresses 020H - 027H are selected.

The first half of IC1802 decides whether the address relates to the analog circuits (addresses 020H - 023H) or the digital circuits (024H - 027H). If analog, the on-chip decoding of IC1804 is used. If digital, the second half of IC1802 is used to determine whether a Read or Write has been performed. A Write will generate a pulse to IC1806 which will store the current state of the data bus. The output of IC1806 is buffered by half of IC1803 to provide the digital output port. A Read will cause the outputs of the second half of IC1803 to be enabled, allowing the data bus to reflect the logic states of the Input port. At the same time TR1801 will be enabled, pulling data line D7 low, which is used by the microprocessor to determine the presence of an Analog Option at power-up.

IC1804 contains three software-programmable timers. The first of these is used as a rate generator, generating a 347Hz rectangular wave (pin 10). The other two timers each take this base frequency and act as programmable monostable flip-flops, generating variable pulse width signals. These signals will normally be 0-5V TTL and are used to switch the analog switch IC1807 between 0V and a negative reference of -6.3 to -7.2 volts.

The resulting negative-going rectangular signals feed into 3-pole low-pass filters (IC1808 and IC1809). Each filter contains an inverting stage to convert the output to a positive-going dc level, and each incorporates pre-set offset and scale adjustments to compensate for circuit tolerances. These may be adjusted and the circuit performance verified as follows, using built-in test software.

1 With the Analog Output board fitted and Main Index selected, the option ANALOG SET should be displayed. (Failure for this to show implies that address decoding or one of the data lines has failed). Select ANALOG SET, set the ANALOG ON/OFF to OFF, and set the UPPER OFF LEVEL to MIN. Connect a DVM on 1V dc range to TP2(+ve) and TP1. Set the output voltage to between -1mV and 1mV by adjusting R1810 (upper zero).

2 Set the UPPER OFF LEVEL to MAX. Set the output voltage to between 0.999 and 1.001V by adjusting R1824 (upper scale).

3 Set the UPPER OFF LEVEL to MID. Switch the DVM to an rms ac range and check that the ripple is less than 10mV rms.

4 Select Code 0.65. Set DVM to 2V dc range. Using the ▲ and ▼ keys, step the output voltage from 0.0V to 1.0V dc, checking that the dc output voltage is within ±1mV of the value displayed on the Analyzer at each step.

5 Connect the DVM between TP3 (+ve) and TP1 and repeat steps 1 to 4, setting LOWER instead of UPPER and adjusting R1815 for zero and R1814 for scale.

6 Connect an oscilloscope between TP2 (signal) and TP1 (ground). Select 200mV/div and 20ms/div. Select Main Index, followed by Code 0.6. Overshoot on the 10Hz square-wave should be less than 100mV, and the settling time less than 35ms.

7 Transfer the oscilloscope signal input to TP3 and repeat step 6.
Remove the DVM and oscilloscope.

2.35 POWER SUPPLIES/GROUNDING

Power Supplies Circuit Diagram - Fig. 6.27.

IMPORTANT See Notes on Fig. 2.4.

The power supply unit comprises analog supplies, a 5-volt supply and a floating bias supply (see Fig. 2.4). Additionally, there are ±12V regulators, bias control circuits and local supply regulators. Although the designs of these individual circuits are based on conventional principles, it is essential that no ground (or return) paths are introduced additional to those in the diagram. Failure to observe this will introduce loops that could seriously affect proper operation of the Analyzer.

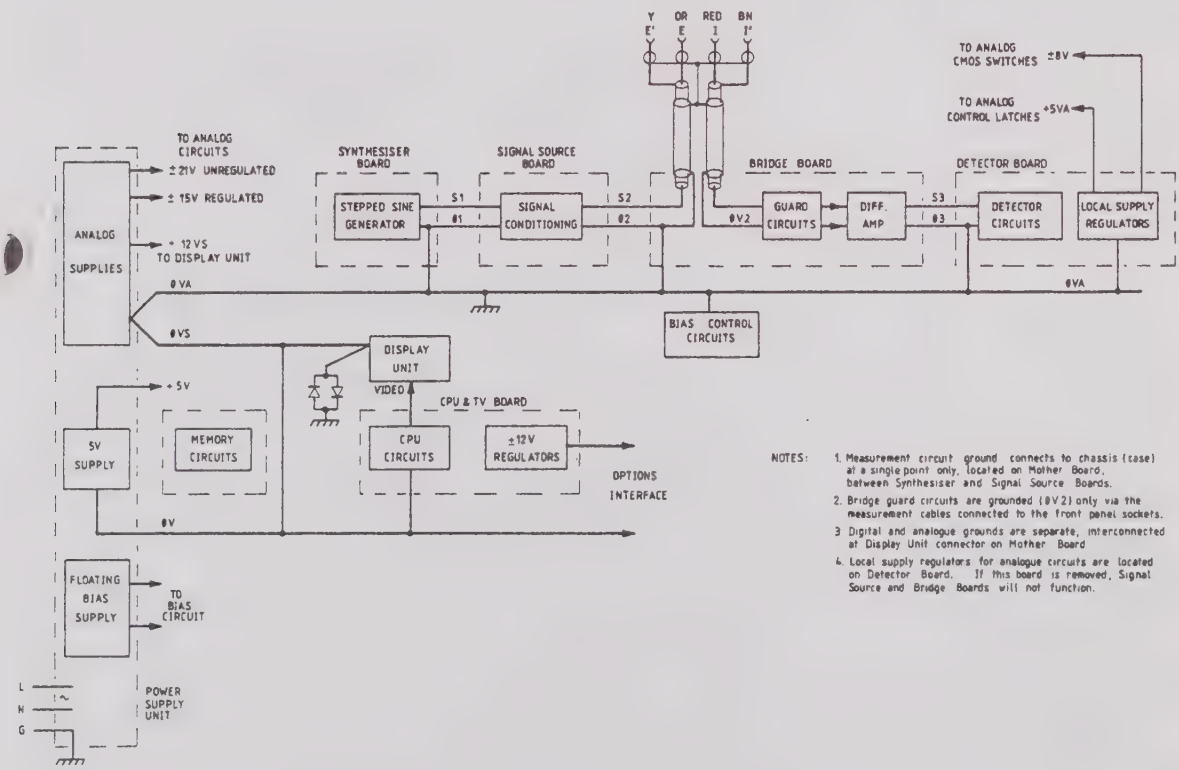
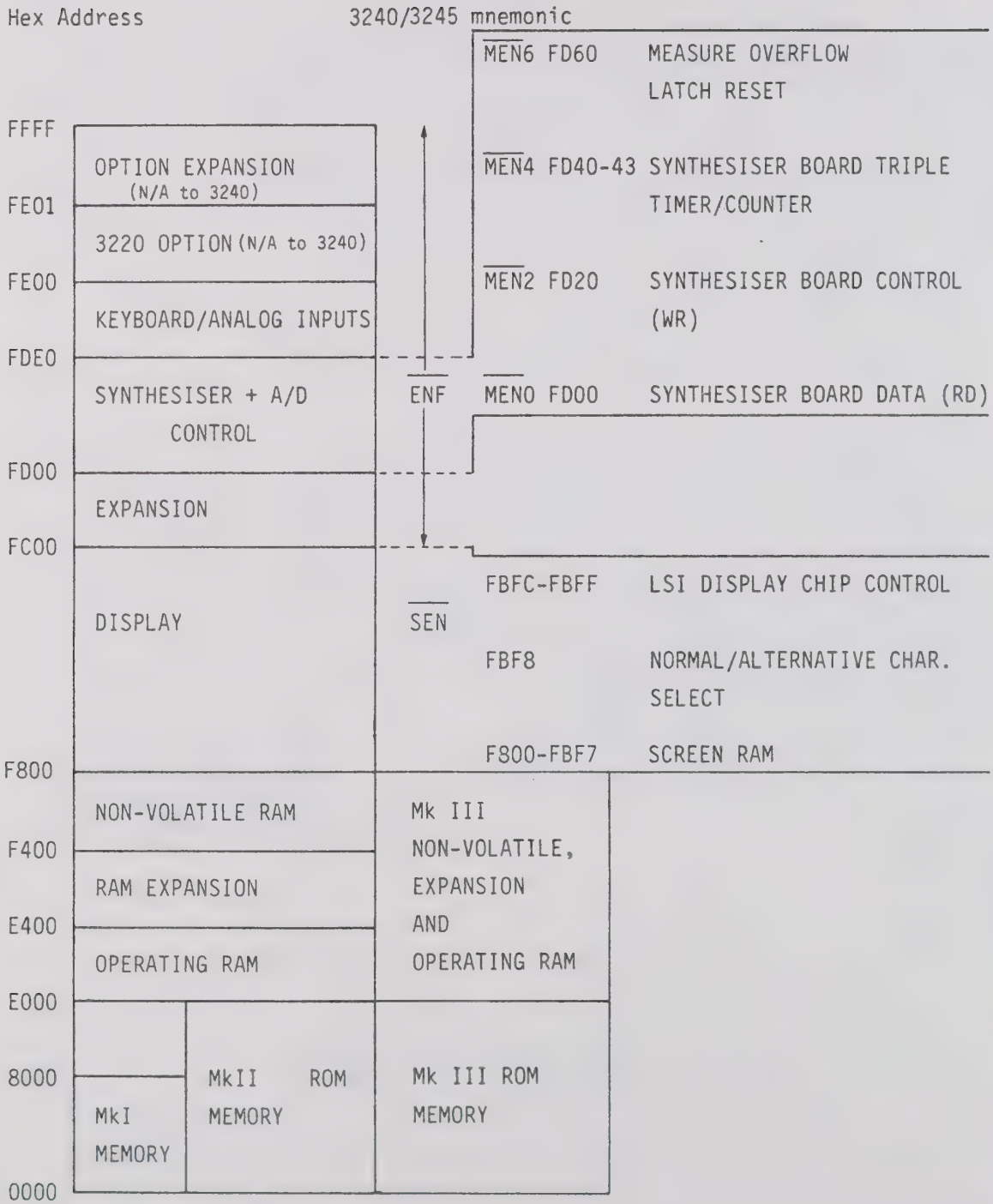


Fig. 2.4 Grounding and Power Supplies

2.36 ADDRESS MAPS

2.36.1 Memory Map



2.36.2 I/O Map

Hex Address

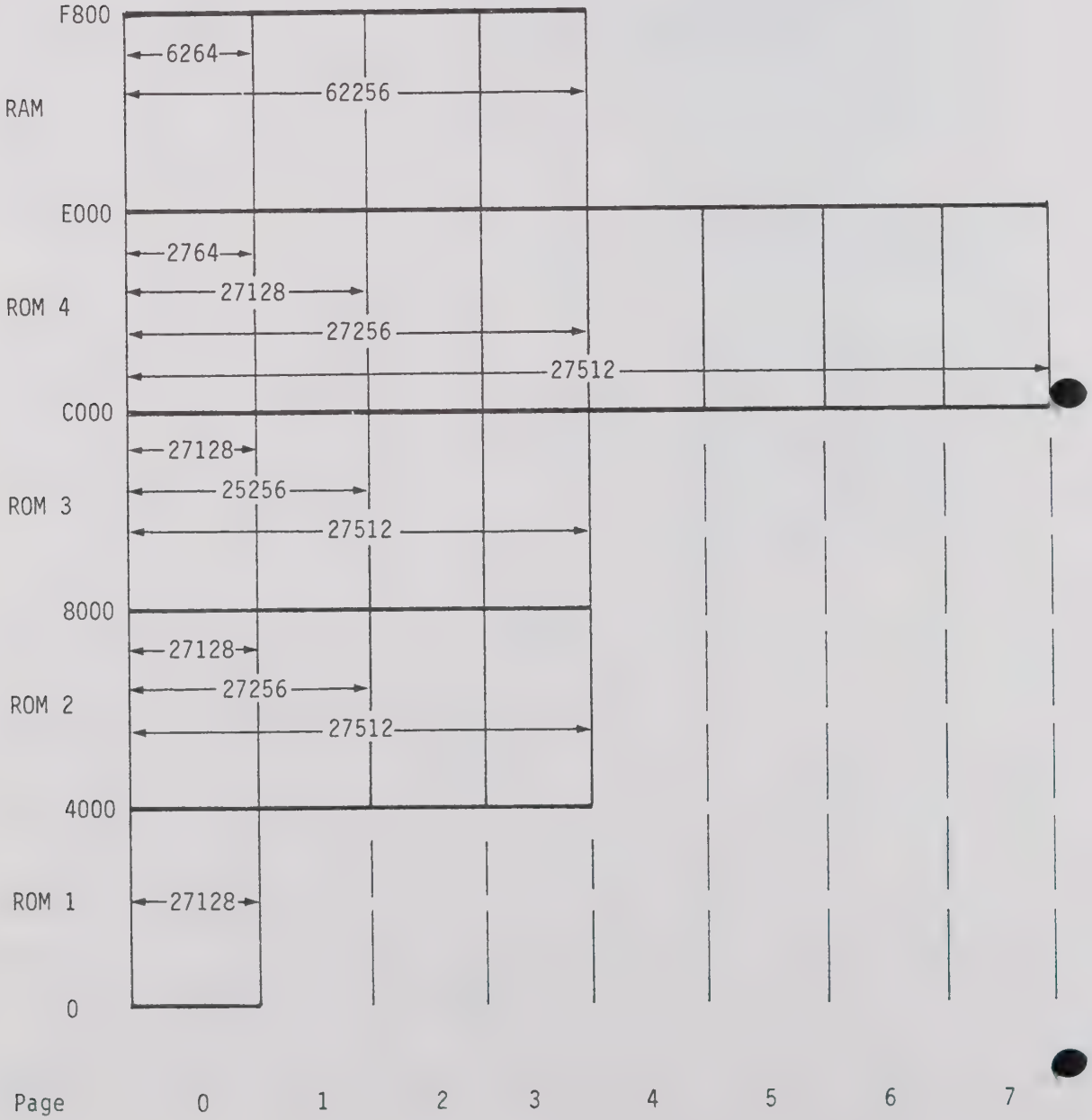
(see circuit description for detailed hardware truth tables)

FF	EXPANSION	
86	INTERNAL 1A	$\overline{OEN}$ 6
85	BIAS CONTROL	$\overline{OEN}$ 5
84	DETECTOR CONTROL	$\overline{OEN}$ 4
83	NEUTRALIZER CONTROL	$\overline{OEN}$ 3
82	BRIDGE CONTROL	$\overline{OEN}$ 2
81	SIGNAL SOURCE CONTROL	$\overline{OEN}$ 1
80	AC LEVEL CONTROL	$\overline{OEN}$ 0
50	OPTION EXPANSION (N/A to 3240)	
40	3210 OPTION (N/A to 3240)	
30	SHI OPTION (N/A to 3240)	
20	ANALOG OPTION (N/A to 3240)	
10	GPIB OPTION (N/A to 3240)	
00	RS232C OPTION (N/A to 3240)	

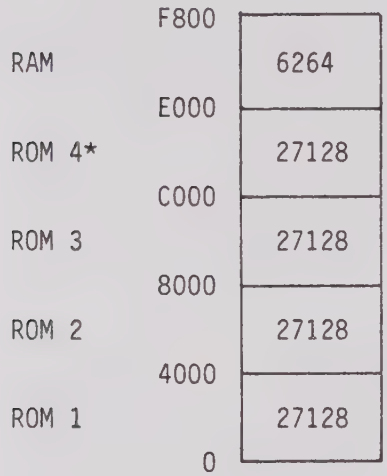
2.36.3 Mk III Memory Board

The Mk III Memory Board supports a paged structure as shown below.

ROM 1 is a 27128.
ROMs 2 and 3 may be 27128, 27256 or 27512.
ROM 4 may be 2764, 27128, 27256, 27512 or not fitted.
RAM may be 6264 or 62256.



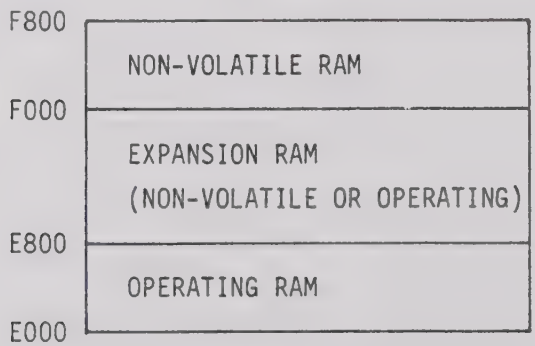
As fitted for software versions up to 8.X, ROMs 1-3 are 27128, ROM 4 is omitted and RAM is 6264. For versions 9.0 onwards, ROMs 1-4 are 27128, and RAM is 6264. Page 0 only is used, giving the memory map as shown:



* Software version 9.0 onwards

Mk III Memory Map (as used)

The Non-Volatile RAM, Operating RAM and RAM Expansion is defined in software, and is as shown in 2.36.1 for software up to version 9.0. For version 9.0 onwards, the map is as shown below



3 DISMANTLING

WARNINGS

> Safety goggles should be worn when handling cathode-ray tubes. Also, the inherent capacitance of the crt can retain a very high voltage charge for several minutes after the instrument has been switched off: this should be shorted to chassis before any work is done on the display circuits.

> For personal safety, and to prevent possible damage to components, always allow 1 or 2 minutes from switch-off for reservoir capacitors to discharge. Check that all rail potentials have decayed before working on the circuits.

On rear lip of the top cover, turn 2 screws (using a 4mm a/f wrench, or screwdriver, according to type fitted) counter-clockwise until a resistance is felt (do NOT attempt to remove them). Raise rear lip slightly and push the cover forward to clear front lip. Remove cover. A similar procedure applies for removal of the bottom cover, if this is necessary.

To release the board retaining plate, remove 2 screws holding the plate to 2 round pillars, and lift this edge to lower the 'outer' end of the plate, clearing it away from 2 studs. The 6 front boards are now accessible.

With top and bottom covers removed, 4 screws are visible which can be removed to release the front panel. To remove rear panel, power transformer screws must also be removed (see Power Supply Unit removal on next page). DO NOT remove front and rear panels at one time or the assembly will collapse. The position of the pcbs and other major items is shown in Fig. 3.1.

Access to individual boards is obtained as follows:

CPU & TV - straight pull

Memory - remove the 64-way connector, raise board some 10cm and push the locking tabs open to release the 10-way header plug. The board can now be withdrawn. (To replace the header plug, push until it clicks into position).

Synthesiser - straight pull.

Bridge - raise the board until the 8-way screened measurement connector can be held across its ends for removal. The board can now be removed with its screening plate attached.

Detector - straight pull (board with its screening plate).

Signal Source - " " " " " " "

Keyboard - remove front panel. Unsolder leads to Trigger socket (or remove socket). Remove 7 nuts to separate the Keyboard.

Internal Bias - first remove CPU & TV, Memory and Synthesiser boards (as described above). Remove 20-way ribbon connector from Mother board. From the Bias board, remove the 2-pin Molex connector (with leads to Bias Link). Using a 2.5mm a/f wrench between the heat-sink fins, remove the two hexagon-socket screws holding the board mounting bracket to the rear panel. When free, disconnect the flying lead 3-pin Molex from the Power Supply board.

Power Supply Board - remove 3 Molex connectors from the Board (1 to reservoir capacitors, 1 to power transformer and 1 to Bias board), and the flying-lead with Molex from the Mother board. Use a wrench (as just described for Internal Bias board) to free board bracket from back panel.

Option boards (N/A to 3240) - the top cover of the Analyzer, and the board retaining plate, must be removed when inserting or removing option boards. Usually, it will also be necessary to remove the Detector and/or Signal Source boards. Options are held by 2 captive screws (top and bottom of their panels) and have 64-way connectors mating to their inside edge.

Display Unit - see WARNING at beginning of section 3. Remove the 6-way Molex connector from Mother board (the connector on the Display Unit varies with supplier). From inside the Analyzer, remove four screws from the base and one (on most models) from the top corner bracket. The complete unit can now be withdrawn.

Power Supply Unit - this is bolted to the rear panel and the two items should not be separated. To obtain access to the Power Supply Unit, remove the bottom cover. This exposes 2 screws into power transformer. Remove these and the 4 screws holding the rear panel to the main framework. Before separating the rear panel, remove connectors as necessary and separate one end of the on/off switch rod (twist to break adhesive bond). Unless

previously removed, the rear panel will carry with it the Power Supply and Internal Bias boards, together with any Options.

Re-assembly is the reverse of the procedures above. Always check that the connectors are correctly positioned and securely fitted; in some instances this must be done before the board is re-fitted to the Analyzer.

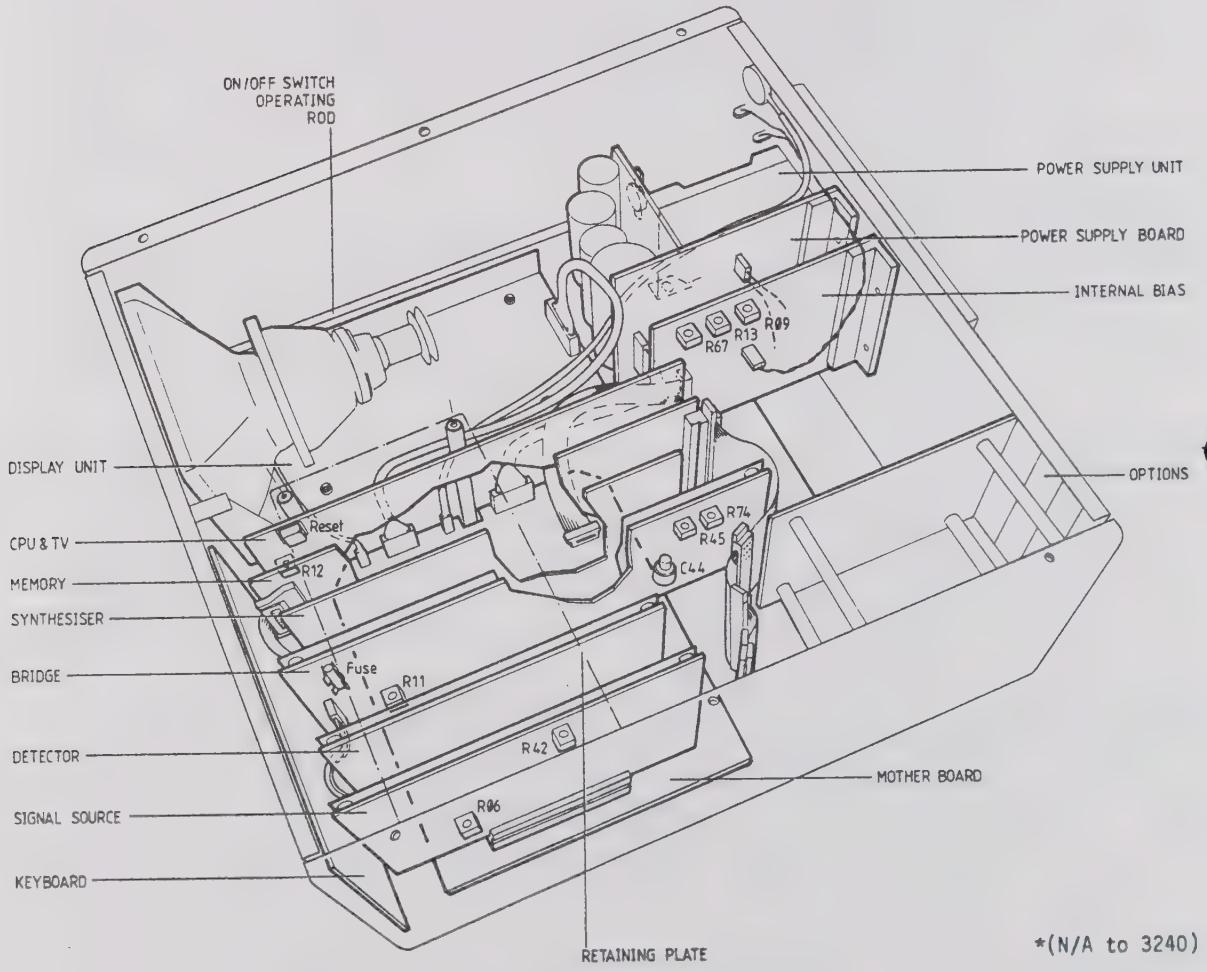


Fig. 3.1 Main Layout

4 TEST EQUIPMENT REQUIRED

4.1	Current Meter	To measure dc currents of 10µA ±1µA, 250mA ±1mA, 1A ±10mA. Multimeter set to dc current range
4.2	DC Voltmeter	To measure dc voltages of 0-50mV, resolution ±1mV. Multimeter set to measure dc volts
4.3	AC Voltmeter	To measure ac voltages in the frequency range 20Hz to 300kHz. Average or rms responding, rms sine-wave calibrated Level range 0.5mV - 10mV accuracy ±3% 10mV - 5V accuracy ±0.1% Bandwidth 1MHz (or use item 4.4) Screened input lead, terminated BNC plug
4.4	Low-pass Filter	To reduce bandwidth of AC Voltmeter to 1MHz nominal for levels below 10mV. See Fig. 4.1 for suitable circuit
4.5	Frequency Counter	To measure 8kHz to 0.001%
4.6	Oscilloscope	Input sensitivity range 10mV/div to 1V/div. Bandwidth >1MHz
4.7	10Ω Resistor	Connected across BNC plug. Value measured at plug: 10Ω ±0.1%
4.8	500µF Capacitor	Connected across BNC plug. Electrolytic or tantalum type, low voltage working, +ve end to centre pin of plug. Value of series capacitance measured at 20Hz: 500µF ±10%
4.9	100Ω Resistor	Wire-ended. Rating 5W. Value 100Ω ±1%

4.10	100mH Inductor	Air-cored inductor. Value 100mH ±5%, dc resistance 7Ω max. Self-resonance ⟨50kHz. See Fig. 4.2 for winding details
4.11	100:1 Transformer	Toroidal-wound precision auto-transformer. Step-down ratio at 10kHz, 100:1 ±0.02%. Secondary impedance at 300Hz >40Ω. Q at 300Hz >1.
4.12	Standards	Screened, 4-terminal Standards terminated in four BNC connectors. See Fig. 4.3 for details of wiring. Screens isolated from Ground.
	R Values	Known values are relative to S/C.
		1.00Ω ±1%. Known value ±0.01%
		10.00Ω ±1%. " " ±0.01%
		80.00Ω ±1%. " " ±0.01%
		640.0Ω ±1%. " " ±0.01%
		5.12kΩ ±1%. " " ±0.01%
		470Ω ±1%.
	C Values	Known values are relative to O/C.
		385pF ±1%. Known value ±0.01% *
		3.08nF ±1%. " " ±0.01% *
		24.6nF ±1%. " " ±0.01% *
		20nF ±2.5%. Polystyrene. Dissipation factor at 100Hz and 10kHz ⟩0.0001
4.13	Extender Board	Single Eurocard size fitted with DIN 41612 64-way a/c indirect connectors
4.14	Variac	100VA minimum rating
4.15	Test Lead	Screened 50Ω lead with two BNC connectors for Oscilloscope/Counter/DC "Link"

* Dissipation factor known to ±0.0001 at 100Hz & 10kHz

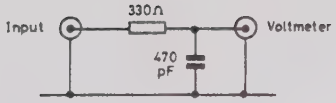
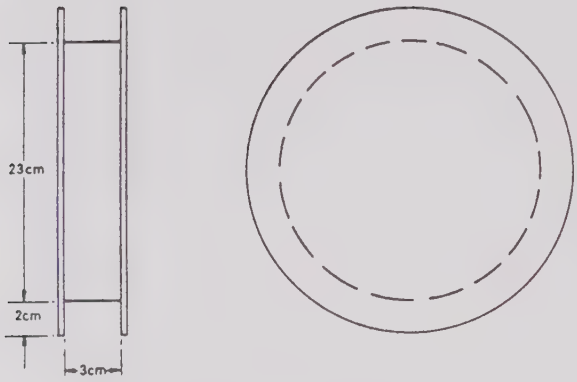


Fig.4.1 Low-pass Filter



DIMENSIONS OF COIL FORMER

Fig. 4.2 100mH Test Inductor

WINDING DETAILS

520 turns 1mm dia. grade 2 enamelled copper wire, wound in layers with 0.15mm paper interleaving between layers.
Measure inductance at 10kHz and remove turns as necessary to obtain 100mH ±5%.

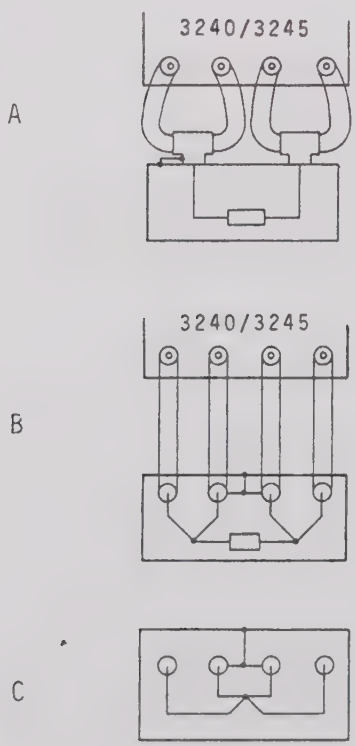


Fig. 4.3 Screened Standards

Notes on Standards (see Fig. 4.3)

Connections to 3240 & 3245 should always be 4-terminal. (A & B).
Leeds to screened boxes must be 4-terminal for low impedance Standards, with Red and Orange outers linked at box end and connected to box itself. Yellow and Brown outers O/C at box end. (B).
All R Standards, also the 20nF and 24.6nF Standards, must be 4-terminal (B). Lower-value capacitance Standards may be 3-terminal (A) or 4-terminal (B). With 3-terminal Standards, use BNC T-pieces at box end to convert to 4-terminal connections to 3240 or 3245. (A).
C shows a 4-terminal short circuit.

5 SETTING-UP PROCEDURES

5.1 BATTERY REPLACEMENT

Life of the Lithium battery used in the non-volatile RAM circuits is normally greater than ten years. When replacement is necessary, remove the Memory Board (see section 3) and the old battery, and break the link between TP02 and TP03. Connect the Current Meter (item 4.1) across these test points (+ve to TP02). Fit the replacement battery, taking care to ensure the correct polarity. The CMOS RAM standby current should not exceed 10µA. Remove the meter, replace the link between TP02 and TP03, and refit the Memory Board, ensuring that the Keyboard connector (SK201) is inserted correctly.

5.2 POWER INPUT

Ensure that the rear panel Bias Link is fitted. Verify the supply voltage setting and ensure that the correct supply fuse is fitted. Link the inners of the red and orange measurement connectors. Connect the instrument to the ac supply via the Variac (item 4.14). Set this to the local nominal voltage, switch on and check that the yellow LED indicator is illuminated.
When the CRT display is visible, select Main Index and NORMAL. Set Bias to 1A and turn it ON. The message 'DC BIAS NOT SET' should extinguish after a few seconds. Use the Variac to set the input voltage to the Analyzer to the low limit (207V for 230V instruments, 103V for 115V instruments). Use the DC Voltmeter (item 4.2) to check dc voltage levels at the regulator board output pins. Pin numbers and acceptable limits are in Table 5.0.

Table 5.0 Internal Supply Tolerances

Output	Nominal	+Pin	-Pin	Limits
*Logic Supply	5.2V	1	2	4.92-5.43
Bias Supply	20.0V	PL02/2	PL02/1	18 - 23
Power Amp Supply (+ve)	+21V	5	8	19.3-24.0
Screen Supply	+12V	6	8	11.4-12.6
Analog +ve Supply	+15V	7	8	14.25-15.75
Analog -ve Supply	-15V	8	10	14.25-15.75
Power Amp Supply	-21V	8	11	19.0 - 25.0

* R710 (value 12R, 33R, 47R or 56R ±5%) is selected during manufacture to achieve correct output voltage. Increasing R710 increases output voltage.

5.3 VOLTAGE TRIP SETTING

Switch off the ac power, remove the CPU & TV Board and connect the DC Voltmeter across TP1 and TP2 (+ve). Refit the Board via Extender Board (item 4.13). Remove the Variac and connect the Analyzer to the ac supply. Switch on. The Voltmeter should read between 4.75 and 4.80V. If necessary, adjust R312. Remove the Voltmeter and re-fit the CPU & TV Board directly to the Analyzer.

5.4 DISPLAY

The Analyzer has an OEM CRT drive circuit. Consequently, setting details and locations of preset controls vary according to manufacturer. Horizontal and Vertical Sync. do not normally need adjustment but, if required, consult the appropriate Appendix.

5.5 BRIGHTNESS

Switch on. Set the Brightness control on the rear panel fully clockwise. Adjust the preset Contrast control on the CRT drive board for maximum brightness of the display without serious defocussing. If necessary, also adjust the preset Brill control until the background level is just invisible. Check operation of the rear-panel Brightness control and set to a normal level.

5.6 ALIGNMENT

Using the keyboard, enter Code 0.2, then press Enter to obtain the CRT test pattern. If miskeying occurs, press Clear and repeat. The centre line on the test pattern should be horizontal. If necessary, slacken the clamp screw on the deflection coil assembly, rotate as appropriate, and retighten the clamp.

If the display height is incorrect, adjust the preset Height or V. Amp control on the CRT drive board.

If the display width is incorrect, adjust the ferrite slug in the Width or H. Amp inductor. Use the correct tool when making this adjustment, or the slug may be damaged.

If the overall display is not centralized, adjust the two shift ring magnets on the deflection coil assembly.

The combined use of these last three adjustments should result in a display pattern which is centralized and approximately fills the screen.

5.7 PIN-CUSHION ADJUSTMENT

If appreciable pin-cushion distortion occurs, the procedure for minimizing it may differ on some models. Do not make any adjustments unless substantial correction is necessary.

If the deflection unit has bar magnets for pin-cushion correction, adjust these by bending them forward and towards the CRT to obtain straight vertical edges on the display pattern. Then adjust ring magnets on the pegs around the display coils, rotating them as necessary to obtain horizontal top and bottom edges on the display. Each of the magnet positions affects one corner or one edge of the display. In the corners of the display it may not be possible to obtain straight horizontal and vertical lines simultaneously on

the test pattern, in which case always adjust for best possible horizontal straightness.
After adjustment, the magnets should be re-locked with suitable cement.

5.8 LINEARITY AND POSITION ADJUSTMENT

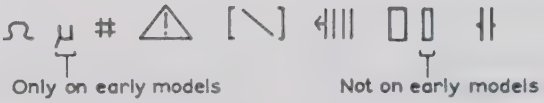
Check the displayed pattern for reasonable horizontal linearity. If obvious differences exist between cell widths at the centre and edges of the display, slacken the deflection coil clamp screw and adjust the linearity sleeve forwards or backwards. Check the display rotation before retightening the clamp.

The vertical spacing between the key legends should correspond exactly to the printed line spacing. If necessary, carefully adjust the display height to achieve this. The display should fill the screen with all details clearly visible: if necessary, make further slight adjustments to the shift ring magnets and width inductor. When set correctly, the key legends should appear in the lower half of their display "windows", when viewed from a position approximately 60cm directly in front of the CRT. If necessary, adjust the linearity presets in conjunction with the height control to obtain this condition for all keys simultaneously. (These presets are labelled Gen. Lin, Bott. Lin or F. Lin.)

Finally, adjust the Focus control for best possible focus at the 4 corners of the test pattern.

5.9 CHARACTER GENERATOR

5.9.1 To test the correct operation of the Character Generator circuits, press Main Index followed by Code 0.1 then Enter. Two versions will be displayed of each upper case letter, lower case letter, numeral and punctuation mark, the lower version being enclosed between two lines. Ensure that these two versions match exactly. The lower line of the display should read



NOTE 'Prom 1' displayed in top righthand corner.*

* Not applicable to some early models.

5.9.2 Press the Enter key to obtain a display of all large-size characters, these being constructed mosaic-wise from special character shapes. Ensure that each character is displayed correctly.

5.9.3* Press Enter. Note 'Prom 2' displayed in top righthand corner. Display should show characters as in 5.9.1, omitting the capacitor.

5.9.4* Press Enter. Large characters should be displayed as in 5.9.2.

5.9.5* Press Enter. Two columns of Bar Graphs should be displayed, the righthand column showing a centre mark. The length of the bar shown should increase from just under 50% at the top of the screen to about 60% at the bottom.

5.9.6 Press Main Index, followed by CONNECTIONS, and ensure all circuit symbols are displayed correctly.

5.10* RAM AND KEYBOARD TESTS

Press Main Index, followed by Code 0.3, then Enter to perform a self-test on the normal (volatile) RAM and the screen RAM.
If no failures occur, the instrument will return to the previous set up conditions. Otherwise a message will appear giving the location of the failure.

Press Code 0.4, then Enter to obtain a Keyboard test pattern. Press each key in turn, finishing with Main Index, to ensure correct operation without bouncing. Press Main Index again to exit from this test.

If it is required to check the Trigger socket, connect the lead or fixture normally used. Press Code 0.4 again, then Enter. Operate the switch on the lead or fixture and check that the effect is the same as pressing the Trigger button on the Analyzer.

5.11 EPROM TEST

Press Code 0.5, Enter, to perform self-test of the main software EPROMS. A cyclic redundancy signature is obtained for each EPROM in turn and its status displayed on the screen. Press Main Index to exit from test.

5.12 TEST CONDITIONS

Press Main Index and select NORMAL.
Select Hold, Single and Norm.
Press Code 6 and Enter to set the Analyzer to range 6.
Select C, R and Parallel.

5.13 SIGNAL SOURCE BOARD

Set frequency to 8.0kHz, level to 10mV ac, bias to 0 Adc and select Bias OFF.

Using the screened lead (item 4.15), connect the Oscilloscope to the orange measurement terminal. With range 6 retained, check that the display on the Oscilloscope is a sinewave of approximately 30mV p-p, with a dc error not exceeding ±10mV. Some hf noise is permitted, not exceeding 30mV p-p, with an Oscilloscope bandwidth of 20MHz.

Select Rdc. The Oscilloscope should show a dc level of 100mV (±10%) with negligible low-frequency ripple. Reselect C.

5.13.1 Bias Setting and Power Up Check

With power off, connect the DC Voltmeter between TP01 (+ve) and TP02 on the Signal Source board. While monitoring the output on the Oscilloscope, switch on the power. Output should go to +100mV for approximately 1.5 seconds before returning to the previous signal conditions. Previously selected display settings should be retained. The DC Voltmeter reading should be 50mV ±10mV. If necessary, adjust Set Bias (preset R542) on the Signal Source board.

Connect the Frequency Counter (item 4.5) to the yellow measurement terminal. Set level to 1.00V ac. The frequency reading should be between 7999.2 and 8000.8Hz.

Switch the Analyzer on and off a number of times and check that the non-volatile display settings are retained. A self-check is performed at power-up and any corruption causes the display to revert to the Main Index mode, with an indication of the memory area that has failed.

5.13.2 Level Setting

Ensure Hold is selected. Key Code 5, Enter, to select range 5. Set level to 1V ac. Set frequency to 1.2kHz. Using a screened lead, connect the AC Voltmeter to the yellow measurement terminal. Check that the reading is 1.00V ±0.5%. If necessary, adjust Set Level (preset R506). Check on the Oscilloscope that the period is 0.8ms.

Set the level to each of the following values and check that the Voltmeter reading is always within the specified limits.

10, 20, 30, 40, 70, 80mV	±2mV
150, 160mV	±3mV
310, 320, 500mV	±5mV
2.5V	2.4625 - 2.5375V
5.0V	4.925 - 5.075V

5.13.3 Source Impedance

Reset level to 1.00Vac. Temporarily replace the Oscilloscope by a 10Ω 0.1% resistor (item 4.7). The AC Voltmeter reading should be between 800 and 820mV. Press Code 1 and Enter to select range 1. The level display should change from 1.00V to 100mA and the AC Voltmeter should read between 812 and 855mV. Remove the 10Ω resistor and reconnect the Oscilloscope.

5.13.4 Frequency Response

Press Code 3, Enter, to select range 3. Select 20Hz and then step upwards through each frequency in turn. At each step, check the Oscilloscope display for a sine wave of approximately the correct frequency and ensure that the AC Voltmeter reading is between the following limits:

20 & 25Hz	0.95 - 1.05V
30Hz - 120kHz	0.975 - 1.025V
150kHz	0.965 - 1.035V
200kHz	0.94 - 1.06V
300kHz	0.90 - 1.10V

The value of C507 (33, 36 or 39pF) is selected during manufacture to achieve the 150kHz to 300kHz values.

5.13.5 Output Coupling Capacitor

Select 20Hz. Replace the Oscilloscope by a 500µF capacitor (item 4.8). The level should not fall below 0.9V. Disconnect the capacitor, AC Voltmeter and Counter.

5.14 BRIDGE BOARD

5.14.1 Bias Setting

Switch off power, and connect DC Voltmeter (item 4.2) between TP01(+ve) and TP02 on the Bridge board. Switch power on and check that the Voltmeter reading is 50mV ±10mV. If necessary, adjust Set Bias (preset R45). Switch off power, and disconnect DC Voltmeter.

5.14.2 Neutralizer Tuning

Connect the AC Voltmeter (item 4.3) to the brown measurement terminal, using a screened lead (item 4.15). If the Voltmeter has a bandwidth exceeding 1MHz, insert the Low-pass Filter (item 4.4) in the input lead, close to the Voltmeter. Connect the 5.12kΩ Standard (see 4.12) between the red and orange measurement terminals.
Set frequency to 60kHz, level to 3.00Vac, and select Hold and Rep.
If Range No. is not displayed, turn it on by keying Code 9, Enter. Key in Code 7, Enter, to select range 7. This should cause the display to blank and RANGE ERROR message to appear. The Voltmeter reading should be less than 4.0mV. If necessary, adjust Set Neutralizer (preset R74) on the Bridge board for minimum Voltmeter reading.
Using the ▼ key, step the frequency downwards to 2kHz. At each step, check that the Voltmeter reading does not exceed the following limits:

40 - 60kHz	4.0mV	
30kHz	2.2mV	
15 - 25kHz	2.0mV	If necessary, the Low-pass Filter
3.0 - 12kHz	0.9mV	bandwidth may be reduced by a factor of
2.0 - 2.5kHz	3.0mV	10 for frequencies of 20kHz and below

Set frequency to 75kHz. The Analyzer should automatically select range 6. Using the ▲ key, check at each frequency up to 200kHz that the Voltmeter reading does not exceed 1.25mV, and that at 300kHz it does not exceed 1.35mV. If necessary, re-adjust R74 to bring all readings within limits. Note that if the first part of this test is to be repeated, range 7 must be re-selected after setting the frequency to 60kHz or below.

5.14.3 Range 1 Input Impedance

With the test equipment connected as for the previous test, replace the 5.12kΩ Standard by a short-circuit between the inners of the red and orange measurement terminals. Key in Code 1, Enter, to select range 1. The drive level should change to 100mA. Set the frequency to 20kHz and check that the Voltmeter reading does not exceed 30mV. Disconnect the AC Voltmeter.

5.15 DETECTOR

5.15.1 Attenuators and DC Level

Using a suitable test probe, connect Oscilloscope to TP02 on the Detector board, making the ground connection to the Detector board screen plate mounting screw. Connect the 640Ω Standard. Enter Code 4 to select range 4.

Set frequency to 1.0kHz, level to 5.00Vac and speed to Fast. The Oscilloscope should display a sinusoidal signal, switching rapidly between two levels. The larger level should be between 1.9 and 2.5V p-p.

Repeat this test with levels of 2.35V, 1.1V, 520mV and 140mV. Some dc shift may occur as the level is reduced. Ensure that the combined peak signal + dc shift does not exceed ±4V total when the level is set to 140mV.

5.15.2 Filters

Set level to 2.35Vac. Set frequency to the following values in turn, in each case ensuring that the larger displayed level is between 1.9 and 2.5V p-p.

30Hz	1.2kHz	50kHz
70Hz	3.0kHz	120kHz
200Hz	8.0kHz	300kHz
500Hz	20kHz	

5.15.3 A-D Converter Waveform

Set speed to Norm. Connect the Oscilloscope probe to TP03 on the Detector board. Set the Oscilloscope sensitivity to 1V/division, dc-coupled, and the timebase to 5ms/division.

Connect the timebase synchronizing input to TP04 and adjust the Oscilloscope to trigger on the -ve going edge of the TTL level pulse present at this point. The Oscilloscope will now display the charge balancing waveforms of the A-D converter. A complete measurement sequence comprises 6 separate measurements, each giving slightly different waveforms and these will appear in succession superimposed on one another. Each waveform should comprise an initial period of 40ms (50ms for 60Hz instruments) during which the voltage oscillates between a maximum of 3.2V and a minimum of 1.8V. The voltage should then fall in approximately 1.5ms to between 0 and -0.2V before returning to 2.5V for 1ms and then repeating (see Fig. 5.1).

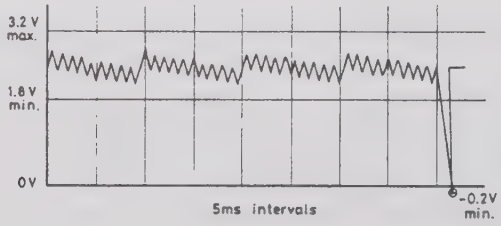


Fig. 5.1 A-D Converter Waveform

Set frequency to 75kHz and ensure these timings are maintained.

Set speed to Fast and check that the initial charge-balancing period changes to 5ms.

Set speed to Slow and change timebase setting to 200ms/division.

The Slow sequence comprises 4 measurements at 200ms and 4 measurements at 100ms. Set frequency to 100kHz and check that these timings become 100ms and 50ms respectively.

Disconnect the Oscilloscope.

5.15.4 Overload Detectors

Select Slow and set frequency to 1.5kHz. With Hold selected, enter Code 5 to select range 5.

Connect the 470Ω Standard between the red and orange measurement terminals.

Set level to 0.92Vac and check that measurement result is blanked.

Inspect the 'measure busy' asterisk (screen top left) and check that it blinks regularly at a rate of approximately 1 per second.

Set level to 1.10Vac and check that the regular blinking is replaced by either a faster irregular blink or a steady asterisk.

Set frequency to 20Hz, check that result is blanked, and that asterisk blinks at a rate of 1 per second.

Set level to 4.3Vac and check that faster blinking or a steady asterisk occurs.

5.16 ACCURACY TESTS

IMPORTANT. Do not attempt any part of these checks unless the test equipment and all the Standards are available. In particular, HF Phase adjustments are inter-dependent: do NOT perform either 5.16.3 or 5.16.10 unless both operations can be completed. It is also vitally important that all trimming operations are made with any connecting leads arranged exactly as they will be for measurement checks. If the leads are changed or moved in any way, the trimming operation must be repeated.

Trimming removes the effect of shunt impedances on high-impedance ranges and series impedance on low-impedance ranges. If Standards are only 2-terminal, the outside connectors must be removed completely (this applies to high impedances: on low-impedance ranges, 4-terminal connections are essential).

Connect the short screened leads that are to be used for connecting Standards.

5.16.1 Initial Trim - O/C

Key in Code 9.1, Enter, to clear down the non-volatile memory. Select NORMAL and set speed to Slow. Set frequency to 10kHz. Select C, R, Parallel and Rep.

Key in Code 9, Enter, to obtain a display of the currently selected measurement range. This should be 7.

Check that the residual capacitance reading does not exceed 20.00pF, with parallel resistance displaying OVERRANGE or a +ve or -ve value of at least 100MΩ.
Press Trim O/C followed by Trigger to initiate the Auto-Trim process. When this is complete, the display should show 25fF or less, with OVERRANGE Ω.

5.16.2 Initial Trim - S/C

Connect a 4-terminal short circuit (see Fig. 4.3). The Analyzer should Auto-range to range 1, the drive level changing to 100mA. Check that the residual inductance and resistance readings do not exceed 350nH and 20mΩ respectively. Press Trim S/C followed by Trigger. When the Auto-Trim process is complete, the display should show 0.0nH ±1.0nH and 0.00mΩ ±0.10mΩ.

5.16.3 HF Phase (ranges 1-6)

Select Hold and key Code 4, Enter, to select range 4. Set speed to Slow and connect the 80Ω Standard, ensuring that the leads are not moved (the slightest movement will cause a greater change than the 0.2μH permitted).
The series inductance reading should be exactly 0.0μH. If necessary, adjust HF Phase (R11) on the Bridge board. Set frequency in turn to 30kHz, 100kHz and 300kHz. In each case, the inductance reading should not exceed ±0.2μH.

5.16.4 Measurement Speed Correlation

Re-set frequency to 10kHz and note exact resistance reading. Select Fast. The inductance reading should be 0μH and the repeated resistance readings should not vary by more than 0.05Ω, each reading being within 0.05Ω of the value noted.

Select Norm. The inductance reading should be 0μH and the repeated resistance readings should not vary by more than 0.01Ω, each reading being within 0.01Ω of the value noted.

.16.5 System Linearity & Distortion

Repeat the S/C Trim and O/C Trim procedures (see 5.16.1 and 5.16.2). Select Auto, C, D, Parallel and Slow. If range number is not displayed, key Code 9, Enter.
Connect the 20nF Polystyrene Standard (see Fig. 4.3).
Set frequency to 10kHz and check that range 5 has been selected. Note the exact C reading.
Set frequency to 12kHz and use the ▼ key to step the frequency downwards to 1.5kHz. At each step, check that

a) range 5 remains selected
b) the change in C reading from the noted value, and the change in C reading from the previous step, do not exceed the limits shown in Table 5.1
c) the D reading, and the change in D reading from the previous step, do not exceed the limits shown in Table 5.1.

Set frequency to 1kHz. Check that range 6 has been selected, and note the exact C reading. Repeat the above test, stepping frequency from 1.5kHz down to 200Hz, and applying the test limits shown in Table 5.2.

Set frequency to 150Hz. Check that range 7 has been selected, and note the exact C reading. Repeat the above test, stepping frequency from 200Hz down to 20Hz, and applying the test limits shown in Table 5.3.
Set frequency to 20kHz. Check that range 4 has been selected, and note the exact C reading. Set frequency to 12kHz and use the ▲ key to step the frequency upwards to 100kHz. At each step, check that range 4 remains selected, and that the changes in C and D readings conform to the limits shown in Table 5.4 as for previous tests.
Set frequency to 120kHz. Check that range 3 has been selected, then select 100kHz and note the exact C reading. Repeat the above test, stepping frequency from 100kHz to 300kHz and applying the test limits shown in Table 5.5.

Table 5.1 (Range 5)

FREQUENCY (kHz)	C LIMIT (nF)	D LIMIT
12	±.002	±.0004
10	Reference	±.0003
8	±.002	±.0003
6	±.002	±.0002
5	±.002	±.0002
4	±.002	±.0002
3	±.003	±.0002
2.5	±.003	±.0002
2	±.004	±.0002
1.5	±.004	±.0002

Table 5.2 (Range 6)

FREQUENCY (Hz)	C LIMIT (nF)	D LIMIT
1.5k	±.002	±.0002
1.2k	±.002	±.0002
1.0k	Reference	±.0002
800	±.002	±.0002
600	±.002	±.0002
500	±.002	±.0002
400	±.002	±.0002
300	±.003	±.0002
250	±.004	±.0002
200	±.004	±.0002

Table 5.3 (Range 7)

FREQUENCY (Hz)	C LIMIT (nF)	D LIMIT
200	±.002	±.0002
150	Reference	±.0002
120	±.002	±.0002
100	±.002	±.0003
80	±.002	±.0004
60	±.002	±.0004
50	±.004	±.0005
40	±.004	±.0006
30	±.006	±.0008
25	±.008	±.0010
20	±.010	±.0012

Table 5.4 (Range 4)

FREQUENCY (kHz)	C LIMIT (nF)	D LIMIT
12	±.002	±.0004
15	±.002	±.0004
20	Reference	±.0004
25	±.010	±.0010
30	±.010	±.0010
40	±.010	±.0010
50	±.02	±.002
60	±.02	±.002
75	±.02	±.002
100	±.03	±.003

Table 5.5 (Range 3)

FREQUENCY (kHz)	C LIMIT (nF)	D LIMIT
100	Reference	±.003
120	±.04	±.004
150	±.06	±.006
200	±.08	±.008
300	±.12	±.010

5.16.6 S/C Trim Interpolation

Re-connect the 4-terminal short circuit as in Fig. 4.3.
If the range number is not displayed, key Code 9, Enter.
Select Auto, Z, Vac and Slow.
Check that range 1 has been selected.
Set frequency to 10kHz and level to 100mA.
During this test, and 5.16.7, ensure that the leads are not moved.
Press Trim S/C, followed by Trigger, to initiate the Auto-Trim process. When this is complete, set frequency to 20Hz and then step through to 10kHz. At each frequency, check that the Z reading does not exceed the following values:

20Hz - 50Hz	0.5mΩ
60Hz - 5kHz	0.25mΩ
6kHz	0.3mΩ
8kHz	0.4mΩ
10kHz	0.5mΩ

At frequencies of 20Hz and 10kHz only, repeat this test with level set to 25mA, (test limit 0.5mΩ) and with level set to 5mA (test limit 4mΩ).
Select L, R and series. Set level to 100mA.
Step frequency from 12kHz to 300kHz. At each frequency ensure that the L and R readings do not exceed the following values:

FREQ (kHz)	L max (±nH)	R max (±mΩ)
12	10.0	0.60
15	10.0	0.76
20	10.0	1.00
25	10.0	1.25
30	10.0	1.50
40	10.0	2.00
50	10.0	2.5
60	10.0	3.0
75	10.0	3.8
100	10.0	5.0
120	10.0	6.0
150	10.0	7.6
200	10.0	10.0
300	10.0	15.0

At 300kHz only, repeat this test with level set to 25mA (test limits ±10nH and ±15.0mΩ) and with level set to 5mA (test limits ±80nH and ±120mΩ).

5.16.7 Low Impedance Accuracy (10kHz)

After performing the previous test, select Hold.

Set frequency to 10kHz and level to 100mAac.

Select each of the following range and Standard combinations in turn, using the corresponding Code no. to select each range. In each case, ensure that the R reading corresponds to the known Standard value, within the tolerance shown, and that the L reading does not exceed the limits shown. Ignore the RANGE ERROR message which appears on range 2 with 1Ω selected.

Range No	Standard	R Tolerance	L Limit*	
			Min	Max
1	1Ω	±.0005Ω (±0.5mΩ)	+10nH	+30nH
2	1Ω	±.0008Ω (±0.8mΩ)	+6nH	+34nH
2	10Ω	±.005Ω	-60nH	+100nH
3	10Ω	±.005Ω	-.06μH	+0.10μH
3	80Ω	±.06Ω	-1.00μH	+1.00μH
4	80Ω	±.04Ω	-0.3μH	+0.3μH
4	640Ω	±.50Ω	-7.6μH	+7.6μH

For range 4 640Ω only, repeat the test with level set to each of the following values:

5.00Vac
2.35Vac

520mVac
140mVac
50mVac

5.16.8 Low Impedance Accuracy (100Hz)

Select range 1 and set level to 100mAac.

Set frequency to 100Hz, then repeat the whole section 5.16.6 with the following test limits:

Range No	Standard	R Tolerance	L Limit
1	1Ω	±.0005Ω (±.5mΩ)	±0.80μH
2	1Ω	±.0008Ω (±.8mΩ)	±1.2μH
2	10Ω	±.005Ω	±8.0μH
3	10Ω	±.005Ω	±8μH
3	80Ω	±.06Ω	±95μH
4	80Ω	±.04Ω	±0.06mH
4	640Ω	±.50Ω	±0.76mH

* Figures quoted assume Standard resistors have a self-inductance of 20nH relative to reference S/C. Other Standards may differ.

5.16.9 O/C Trim Interpolation

Remove all connections from the measurement sockets.

If the range number is not visible, key Code 9, Enter.

Select Auto, Z, Iac and Slow.

Set frequency to 10kHz and level to 5.00V.

Check that range 7 has been selected.

Press Trim O/C, followed by Trigger, to initiate the Auto-Trim process. When this is complete, set frequency to 20Hz and then step through to 10kHz. At each frequency, check that the Z reading is OVERRANGE or a value not less than the following:

20Hz - 50Hz	350MΩ
60Hz - 10kHz	700MΩ

At frequencies of 20Hz and 10kHz only, repeat this test with level set to 250mV (test limits unchanged) and 50mV (test limits become 40MΩ and 80MΩ respectively with range 6 selected).

Select C, R and Parallel. Set level to 5.00V.

Step frequency from 12kHz to 300kHz. At each frequency, check that correct range is selected and that the C reading does not exceed the following values. Also check that the R reading is OVERRANGE, or a value not less than the following:

FREQ (kHz)	RANGE	C Max	R Min
12	7	±25fF	±500MΩ
15	7	±25fF	±450MΩ
20	7	±25fF	±350MΩ
25	7	±25fF	±250MΩ
30	7	±25fF	±200MΩ
40	7	±25fF	±160MΩ
50	7	±25fF	±120MΩ
60	7	±25fF	±100MΩ
75	6	±0.20pF	±10MΩ
100	6	±0.20pF	±8MΩ
120	6	±0.20pF	±7MΩ
150	6	±0.20pF	±5MΩ
200	6	±0.20pF	±2MΩ
300	6	±0.20pF	±2.5MΩ

At frequencies of 60kHz and 300kHz only, repeat this test with level set to 250mV (test limits ±50fF ±50MΩ range 7 at 60kHz, ±0.20pF ±2.5MΩ range 6 at 300kHz) and to 50mV (test limits become ±0.400pF ±6MΩ range 6 at 60kHz, and ±1.6pF ±300kΩ range 5 at 300kHz).

5.16.10 High Impedance Accuracy (10kHz)

After performing the previous test, select Hold, C, D and Parallel.

Set frequency to 10kHz and level to 1.00Vac.

Select range 7 and connect the 385pF Standard capacitor.

The D reading should correspond exactly with the known D value of the capacitor at 10kHz, with a variation due to measurement noise not exceeding ±0.0001. If necessary, adjust Range 7 Phase (C844) on the Bridge board.
Check that the C reading is within ±0.20pF of the known Standard value.
Disconnect the brown and yellow measurement leads at the Analyzer end. If the Standard is 4-terminal, connect all four outers together at the Standard end of the leads. Check that the change in C reading does not exceed ±0.01pF and that the change in D reading does not exceed ±0.0002.
Re-connect the brown and yellow measurement leads to the Analyzer and, if the four outers were linked at the Standard end, remove the link.

Select each of the following range and Standard combinations in turn, using the corresponding Code no. to select each range. In each case, check that the C and D readings correspond to the known Standard values within the tolerances shown.

Range No	Standard	C Tolerance	D Tolerance
6	385pF	±0.30pF	±.0008
6	3.08nF	±0.0016nF	±.0005
5	3.08nF	±0.0024nF	±.0008
5	24.6nF	±0.012nF	±.0005

With range 5 held, connect the 640Ω Standard. Select C, R and Parallel.

Check that the R reading corresponds to known Standard value ±0.30Ω with a +ve or -ve C reading not exceeding 12.0pF.

5.16.11 High Impedance Accuracy (100Hz)

With settings retained from the previous test, set frequency to 100Hz. Select each of the following range and Standard combinations in turn. In each case, check that the R reading corresponds to known Standard value within tolerance shown, with a +ve or -ve C reading not exceeding the limit shown.

Range No	Standard	R Tolerance	C Max
5	640Ω	±0.30Ω	1.20nF
5	5.12kΩ	±0.0035kΩ	0.23nF
6	5.12kΩ	±0.0025kΩ	150pF

Select C, D and Parallel.

Select the following range and Standard combinations in turn.

In each case, check that the C and D readings correspond to the known Standard values within the tolerances shown. Ignore the RANGE ERROR message which appears for the first measurement.

Range No	Standard	C Tolerance	D Tolerance
6	24.6nF	±.018nF	±.0008
7	24.6nF	±.012nF	±.0005
7	3.08nF	±.0024nF	±.0008

5.16.12 DC Resistance

Select Rdc and Slow.

If the range number is not displayed, key Code 9, Enter.

Key Code 22, Enter to select the Normal Rdc measurement range. (Range indicator to show N).

Connect each of the following Standards in turn. In each case, check that the R reading corresponds to the known Standard value within the tolerance shown. Ignore the RANGE ERROR indication which occurs with the S/C and 1Ω settings.

If these results are not achieved, carry out the Trim O/C and Trim S/C procedures before repeating the test.

Standard	Tolerance
S/C	0 ±5mΩ
1Ω	±.005Ω
10Ω	±.02Ω
80Ω	±.100Ω
640Ω	±1.0Ω
5.12kΩ	±.01kΩ
O/C	OVERRANGE

Key Code 21, Enter, to select the Low Rdc measurement range. (Range indicator to show L). Repeat the above test for the following settings only:

Standard	Tolerance
S/C	0±0.5mΩ
1Ω	±.005Ω

5.17 DC BIAS & CURRENT SETTING

Switch off power and remove any Standard component. Link together the red and orange measurement connectors using a short screened lead.

5.17.1 DC Bias

With power off, connect the DC Voltmeter between TP01 (+ve) and TP02 on the Bias Current board.
Switch on power. The Voltmeter reading should be 0V ±10mV. If necessary, adjust the Trip preset (R67).
Switch off power and remove Voltmeter.

5.17.2 Current Setting

With power off, remove the Bias Link from the rear panel and connect the Current Meter (item 4.1) across the Bias Link terminals. Switch on.
Select L, D, Series, Auto and Slow.
Set frequency to 10kHz, level to 100mAac and Bias to 4mAdc.
Select Bias ON.
The meter reading should be 4mA ±0.1mA. If necessary, adjust Offset preset (R13) on the Bias Current board.
Set Bias to 250mAdc. The meter reading should be 250mA ±1mA. If necessary, adjust Set preset (R09).
Repeat these adjustments until all interaction is eliminated.

5.17.3 Bias Current Accuracy

Set Bias to each of the following values. In each case, check that the current reading is correct to ±2.5%.

50mA	(±1.25mA)
100mA	(±2.5mA)
500mA	(±12.5mA)
1.0A	(±25mA)

Set Bias to each of the following values, checking the reading accuracy as shown:

1,2,3,4,7,8mA	±0.25mA
15,16mA	±0.5mA
31,32,50mA	±1.25mA

Remove link from red and orange terminals. Check that DC CURRENT NOT SET message appears, followed by EXCESS VOLTAGE DROP and then, after about 15 seconds, SAFETY: BIAS TURNED OFF.

Check that the Bias is OFF.
Replace link between red and orange terminals.

5.17.4 Voltage Trip

Select Bias OFF.
Replace current meter by a 100Ω (1% 5W) resistor (item 4.9).
Select Bias ON and set Bias to 120mAdc. The message DC CURRENT NOT SET should extinguish after approximately 1 second, and no message appear in its place.

Set Bias to 180mAdc. Check that the message EXCESS VOLTAGE DROP appears.
Set Bias to 1.0Adc. Check that the EXCESS VOLTAGE DROP message remains.

5.17.5 Measurement Accuracy

SAFETY WARNING

> The back-emf from the test inductor may be lethal.
> Always ensure that the direct current is at zero before disconnecting the inductor.

Select Bias OFF and refit Bias Link on rear panel.
Connect the 100mH Test Inductor (item 4.10) between the red and orange measurement sockets, positioning it at least 30cm away from the Analyzer and from any ferrous metal object.

With Analyzer settings retained from previous tests, note the exact L and D readings obtained. Set Bias to 250mAdc and select Bias ON.

Wait for DC CURRENT NOT SET message to extinguish.

Check that the change in L reading from the noted value does not exceed ±0.2mH.

Check that the change in D reading from the noted value does not exceed ±0.001.

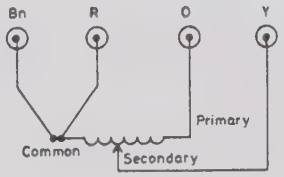
Set Bias to 1.0Adc. Wait for the message DC CURRENT NOT SET to extinguish. Check that the change in L reading from the noted value does not exceed ±1.8mH.

Check that the change in D reading from the noted value does not exceed ±.018.

Select Bias OFF, wait for the message DC CURRENT NOT SET to extinguish and then remove Test Inductor.

5.18 TRANSFORMER MEASUREMENT

Connect the 100:1 Test Transformer (item 4.11) to the four measurement terminals as shown below.



Press Main Index followed by TRANSFORMER to select the transformer measurement mode.

Select Ratio, Np/Ns, Auto and Norm.
Set frequency to 10kHz and level to 5.00Vac.
Check that the Analyzer reading is between 99.9 and 100.1.
Set frequency to 300Hz.
Interchange the orange and yellow measurement connectors. The message LEVEL TOO HIGH should appear.
Reduce level to 50mVac and check reading is 0.010 or 0.011.
Remove transformer and all connecting leads from the Analyzer.
Switch off POWER and fit plug-in board retaining plate.

APPENDIX A

KME CRT DRIVE BOARD (MODEL MB1200 D)

A.1 CIRCUIT DESCRIPTION

Circuit Diagram - Fig. 6.31

WARNING

> At no time should the CRT Drive Board be run without the flashover protection system fully connected, (the crt base socket), otherwise extensive damage may result and, because high voltages are generated within the unit, no attempt should be made by unskilled personnel to service a unit whilst it is switched on.

Design of the CRT Drive circuit is based on thick-film hybrid technology. Normally, if a hybrid becomes faulty, the board would be replaced. Note that the links and jumpers shown on the circuit diagram are applicable to the TTL mode of operation used in the 3240 & 3245. (The board has provision for an alternative - composite - mode of operation).

Video amplification is provided by M1, with the gain set by Contrast control VR1, and the video signal drives the crt cathode via C22/D9 and a 1k flashover protection resistor.

The frame timebase is based on IC1 with hybrids M2 and M3, control of vertical amplitude and linearity being provided by VR2, VR3 and VR4. Frame flyback blanking is fed from IC1 pin 3 to M1 pin 6. The frame circuit operates from the boosted supply at IC1 pin 2, derived from the line output transformer, T1.

The line timebase is a Hartley oscillator utilizing M4, L1 and C13, with horizontal hold control VR5. A rectangular pulse at M4 pin 1 is ac-coupled to line output transistor VT1. Primary of the line output transformer is connected to D3 and D4 to provide the boosted rail supply for the frame timebase (referred to in the previous paragraph).

High voltage for focus and A1 of the crt is generated by D5/C19, while D6/C18 derive the negative supply for the brightness control circuit M5 with VR7. M5 also provides line flyback blanking and spot suppression at switch-off. A 68-volt positive supply for the video amplifier is produced by D7/C5. Note that the eht rectifier, D8, is integral with the line output transformer.

The crt socket incorporates spark-gap protection on each of the pins. The ground connection of the spark-gap is pin 3, which is connected directly to the metallized bulb of the crt. Under flashover conditions, very large currents may flow momentarily to ground, and diodes D1002/D1003 (Fig. 6.30: diodes not fitted on some early models) prevent these entering the digital circuits and possibly corrupting the MPU.

A.2 TEST EQUIPMENT REQUIRED

(Where Horizontal or Vertical Sync. require adjustment).

i) Oscilloscope with 10MΩ input probe.

ii) Copper-bladed trimming tool.

A.3 INITIAL CONTROL SETTING

Ensure that PL1, PL2, CRT base, EHT lead, CRT metallizing and 10-way connector are all correctly engaged.

Connect the oscilloscope probe to the cathode (positive) end of D2 and set the vertical and horizontal deflection factors to 2V/cm and 10μs/cm respectively.

Apply dc input and drive signals.

A.4 HORIZONTAL AND VERTICAL HOLD

If there is no horizontal lock, adjust VR5 (H. Hold) until the picture locks in. The exact position of the control does not matter at this stage and will be set accurately later.

If adjustment of VR5 cannot achieve horizontal lock, then put it at the mechanical centre of its travel and adjust the core of L1 with the copper bladed trim tool until the picture is locked.

Vertical lock is preset by resistor R5 and should not require adjustment. Should it be necessary, R5 may be removed and a 100k variable resistor connected across R5 pads and adjusted for vertical lock. The value of the variable should then be measured and the nearest preferred value of fixed resistor soldered into position R5. At this stage all other adjustments should be left until the mark-space ratio of the waveform observed at D2 cathode is verified to be within limits or is adjusted to be so.

A.5 DRIVE PULSE MARK/SPACE RATIO

The waveform observed on the Oscilloscope will be rectangular with a duration equal to the horizontal repetition rate and the negative part of it should lie in the region of 19-21µs. The amplitude will be approximately 7V peak to peak. If the negative duration is wrong then the core of L1 should be adjusted with the copper-bladed trimming tool to give a duration of 20µs. If adjustment of the core causes the monitor to go out of horizontal sync then VR5 must be re-adjusted. Alignment of L1 is valid only with the timebase in lock.

When the mark/space ratio is correct, the centre frequency of the line discriminator circuit is adjusted to give maximum pull-in range as follows:

Short-circuit line sync to ground and rotate VR5 to give a floating picture, i.e. out of but nearly in lock.
Releasing the short will cause the picture to jump into a horizontal lock with the data central in the raster ± 1 character space. Absolute centering may then be achieved by slight re-adjustment of VR5.

It cannot be too highly stressed that the above procedure is the only allowable one, and no deviations are permitted if correct and continued operation of the Analyzer is to be achieved. Under no circumstances must the core of L1 be used as either a horizontal phase or hold adjustment. Once the coil has been aligned it should never need touching again.

APPENDIX B

NEVIN CRT DRIVE BOARD (MODEL DDF 5 Mk II)

B.1 CIRCUIT DESCRIPTION

Circuit Diagram - Fig. B.1 (page B-5)

The function of this board is similar to that described in Appendix A except that integrated circuits are used in place of hybrids.

WARNING

> At no time should the CRT Drive Board be run without the flashover protection system fully connected, (the crt base socket), otherwise extensive damage may result and, because high voltages are generated within the unit, no attempt should be made by unskilled personnel to service a unit whilst it is switched on.

Because the circuit board is common to several different applications, a few components are located in positions which have inapplicable silk screening (for example there is a diode fitted in the location "R16").

B.2 SETTING-UP PROCEDURE

The operations described in sections 5.4 to 5.8 inclusive should be read in conjunction with the text below. The procedure to be used will depend on whether the display tube or the drive board has been disturbed.

1 Set the Brilliance control (RV8) on the drive board to maximum.

2 Adjust Width (L1) so that both edges of the raster are visible.

3 Adjust Phase (RV1) to centralize the cross-hatch pattern on the raster.

4 Re-set Width, and reduce Brilliance to the normal level.

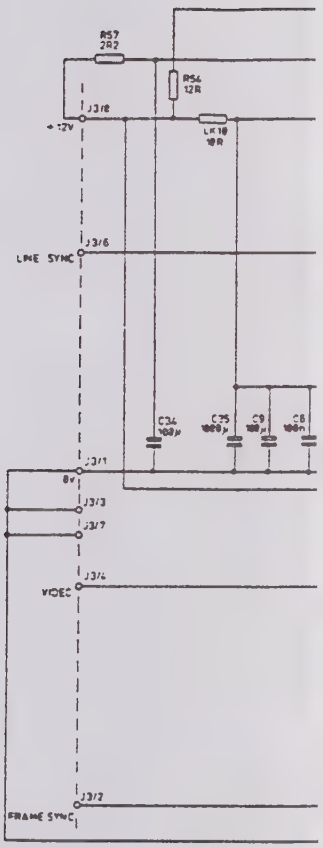
5 The Nevin board has a Hold control (RV3) which can be adjusted if any frame slip occurs.

B.3 NEVIN CRT DRIVE BOARD - COMPONENTS LIST

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R1	100k	2	0.33W	Film	Mullard SFR25
R2	5k6	2	0.33W	Film	Mullard SFR25
R3	5k6	2	0.33W	Film	Mullard SFR25
R4	10k	2	0.33W	Film	Mullard SFR25
R5	100k	2	0.33W	Film	Mullard SFR25
R6	10k	2	0.33W	Film	Mullard SFR25
R7	1k2	2	0.33W	Film	Mullard SFR25
R8	22R	2	0.5W	Film	Mullard SFR30
R9	82k	2	0.33W	Film	Mullard SFR25
R10	10k	2	0.33W	Film	Mullard SFR25
R11	1k8	2	0.33W	Film	Mullard SFR25
R12	470R	2	0.5W	Film	Mullard SFR30
R13	33R	2	0.33W	Film	Mullard SFR25
R14	150k	2	0.33W	Film	Mullard SFR25
R15	10k	2	0.33W	Film	Mullard SFR25
R16	(See diodes)				
R17	270k	2	0.33W	Film	Mullard SFR25
R18	68k	2	0.33W	Film	Mullard SFR25
R19	39k	2	0.33W	Film	Mullard SFR25
R20	5k6	2	0.33W	Film	Mullard SFR25
R21	3R3	2	0.33W	Film	Mullard SFR25
R22	220k	2	0.33W	Film	Mullard SFR25
R23	1M8	2	0.33W	Film	Mullard SFR25
R24	1R0	2	0.33W	Film	Mullard SFR25
R25	5k6	2	0.33W	Film	Mullard SFR25
R26	Not fitted				
R27	(Link)				
R28	47R	2	0.33W	Film	Mullard SFR25
R29	47R	2	0.33W	Film	Mullard SFR25
R30	1k2	2	0.33W	Film	Mullard SFR25
R31	10k	2	0.33W	Film	Mullard SFR25
R32	47R	2	0.33W	Film	Mullard SFR25
R33	1k	2	0.33W	Film	Mullard SFR25
R34	Not fitted				
R35	820R	2	1.6W		Mullard PR37
R42	39k	2	0.33W	Film	Mullard SFR25
R43	12k	2	0.33W	Film	Mullard SFR25
R54	12R	2	0.33W	Film	Mullard SFR25
R55	1k0	2	0.33W	Film	Mullard SFR25
R56	Not fitted				
R57	2R2	5	2.5W	Wire Wound	
LK10	10R	2	0.33W	Film	Mullard SFR25
RV1	10k	Phase		Preset	Piher PT10V
RV2	10k	Line Hold		Preset	Piher PT10V
RV3	100k	Frame Hold		Preset	Piher PT10V
RV4	220k	Height		Preset	Piher PT10V
RV5	100k	General Linearity		Preset	Piher PT10V
RV6	2M2	Focus		Preset	Piher PT10V
RV7	1k0	Contrast		Preset	Piher PT10V
RV8	100k	Brilliance		Preset	Piher PT10V

(NEVIN CRT DRIVE BOARD - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
C1	2µ2	10	100V	Polyester	Wima MK54
C2	10n		63V		Wima FK52100V
C3	22n		63V	Decoupling	Wima R2
C4	4n7	1	160V	Polyester axial	Mullard 42S
C5	100µ		16V	Rad Al El	
C6	100n		63V	Decoupling	Siemens B37449
C7	4µ7		35V	Rad Al El	
C8	4µ7		35V	Rad Al El	
C9	100µ		16V	Rad Al El	
C10	47µ		63V	Rad Al El	
C11	1000µ		16V	Rad Al El	
C12	100µ		16V	Rad Al El	
C13	100µ		16V	Rad Al El	
C14	100n		63V	Decoupling	Siemens B37449
C15	150n	10	100V		Mullard 2222-363-25154
C16	33p	2	100V	Cer. Plate	Mullard 2222-683-58339
C17	100n		100V	High Stab.	Siemens B32560
C18	3n3		63V		Wima FK52100V
C19	100n		100V	High Stab.	Siemens B32560
C20	15n		400V		Wima FKC-32
C21	10n		1kV	Ceramic Disc	
C22	Not fitted				
C23	100p	2	100V	Cer. Plate	Mullard 2222
C24	100n		63V	Decoupling	Siemens B37449
C25	10µ		100V	Rad Al El	
C26	220µ		63V	Rad Al El	
C27	150n	10	100V		Mullard 2222-363-25154
C33	1n		63V		Evox MMKO 5
C34	4µ7		16V	Rad Al El	Gelec AE4-7R16
C35	1000µ		16V	Rad Al El	
IC1	TDA 1180P			Line I.C.	SGS
IC2	TDA 1170S			Frame I.C	SGS
D1	1N4006			Diode	Mullard
D2	1N4006			Diode	Mullard
D3	BYV 96E			Diode	Mullard
D4	BZY 88 C8V2 D035			Zener Diode	Mullard
D5	BYV 96E			Diode	Mullard
D6	BYV 96E			Diode	Mullard
D7	BYW 95B			Diode	Mullard
R16	1N4148			Diode	Mullard
TR1	BU806			Transistor	Mullard
TR2	BC547B			Transistor	Mullard
TR3	BC547B			Transistor	Mullard
TR4	BC547B			Transistor	Mullard
J1	4-way Straight Post Header				Amp 640456-4
J3	8-way Straight Post Header				Amp 640456-8
T1	Line Output Transformer				Philips AT2240/16


R57
2R2
R54
12R
J3/8
+12V
LK10
10R
J3/6
LINE SYNC
C34
100µ
C35
100µ
C9
100µ
C8
100n
J3/1
8V
J3/3
J3/7
J3/4
VDEC
J3/2
FRAME SYNC

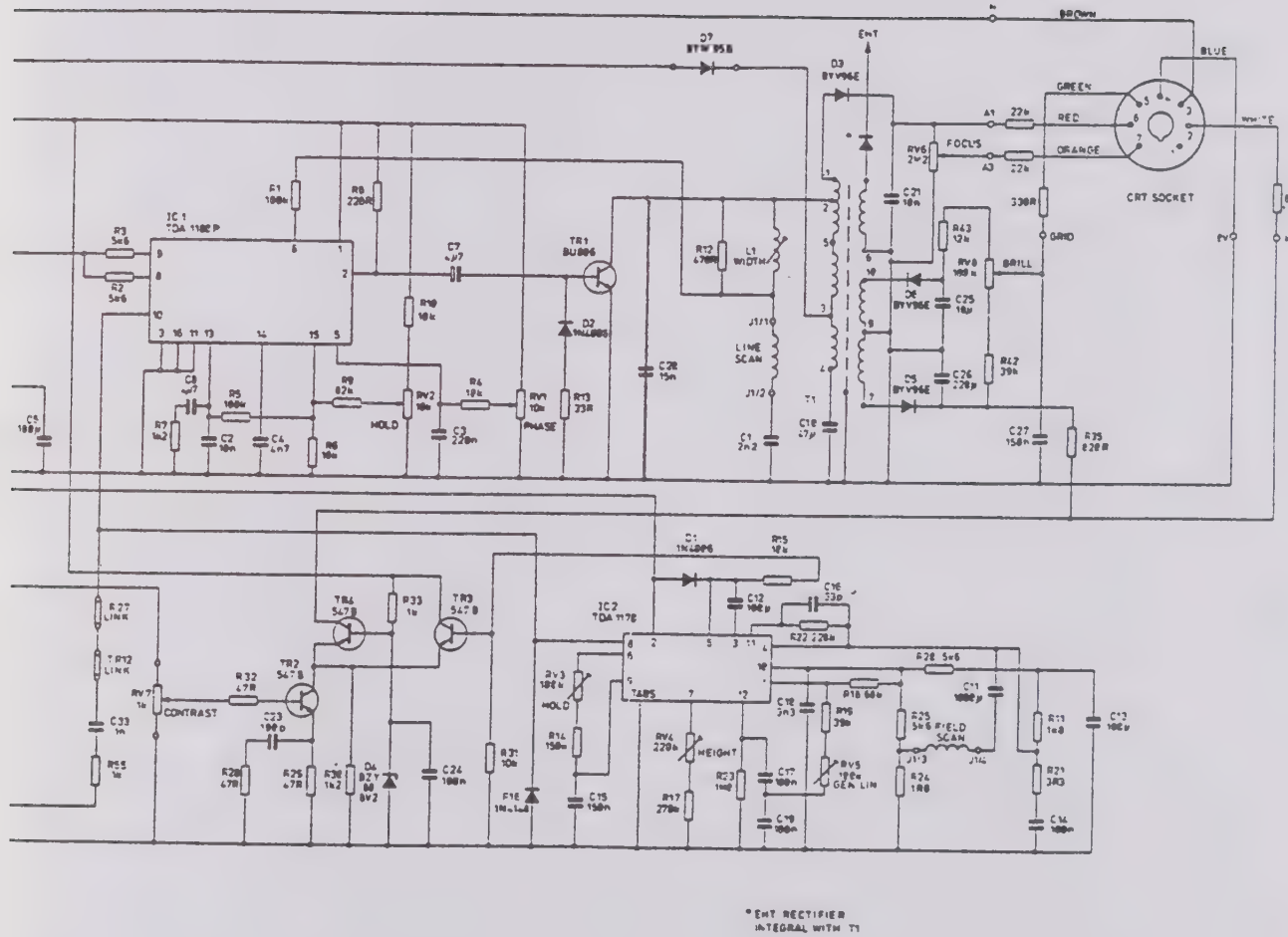


Fig. B.1
Nevin CRT Drive Board - Circuit Diagram
DV/25744

6 3240/3245 COMPONENTS LIST

6.1 SYNTHESISER PCB

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R102	510R	1	100ppm	Metal Film	Allen Bradley FC55
R103	510R	1	100ppm	Metal Film	Allen Bradley FC55
R104	510R	1	100ppm	Metal Film	Allen Bradley FC55
R105	510R	1	100ppm	Metal Film	Allen Bradley FC55
R106	510R	1	100ppm	Metal Film	Allen Bradley FC55
R107	510R	1	100ppm	Metal Film	Allen Bradley FC55
R108	510R	1	100ppm	Metal Film	Allen Bradley FC55
R109	620R	1	100ppm	Metal Film	Allen Bradley FC55
R110	13k0	0.1	50ppm	Metal Film	Allen Bradley FC55
R111	Not fitted				
R112	6k8	0.1	50ppm	Metal Film	Allen Bradley FC55
R113	95R3	1	100ppm	Metal Film	Allen Bradley FC55
R114	4k99	0.1	50ppm	Metal Film	Allen Bradley FC55
R115	20R	2		Metal Oxide	Electrosil TR4
R116	4k64	0.1	50ppm	Metal Film	Allen Bradley FC55
R117	95R3	1	100ppm	Metal Film	Allen Bradley FC55
R118	4k99	0.1	50ppm	Metal Film	Allen Bradley FC55
R119	Not fitted				
R120	6k8	0.1	50ppm	Metal Film	Allen Bradley FC55
R121	Not fitted				
R122	13k0	0.1	50ppm	Metal Film	Allen Bradley FC55
R123	Not fitted				
R124	47R	5		Film	Mullard SFR25
R125	Not fitted				
R126	47R	5		Film	Mullard SFR25
R127	220R	5		Film	Mullard SFR25
R128	1k0			SIL N/W	Hitech L109
R129	1k	5		Film	Mullard SFR25
R130	1k	5		Film	Mullard SFR25
R131	1k	5		Film	Mullard SFR25
R132	Not fitted				
R133	1k	5		Film	Mullard SFR25
R134	1k	5		Film	Mullard SFR25
R135	47R	5		Film	Mullard SFR25
R136	4k7	5		Film	Mullard SFR25
R137	1k	5		Film	Mullard SFR25
C101	100n		63V	Ceramic Disc	Siemens B37449
C102	100n		63V	Ceramic Disc	Siemens B37449
C103	100n		63V	Ceramic Disc	Siemens B37449
C104	100n		63V	Ceramic Disc	Siemens B37449
C105	100n		63V	Ceramic Disc	Siemens B37449
C106	100n		63V	Ceramic Disc	Siemens B37449
C107	Not fitted				
C108	100n		63V	Ceramic Disc	Siemens B37449
C109	220µ		16V	Electrolytic	Dubilier CEA22016
C110	4n7	-20,+80	500V	Ceramic Disc	ITT CD10/K3
C111	270p	20	500V	Ceramic Disc	ITT CD08/K1
C112	1n	-20,+80	500V	Ceramic Disc	ITT CD08/K2
C113	1n	-20,+80	500V	Ceramic Disc	ITT CD08/K2
C114	220n	20	100V	Polyester	Wima MKS4

(3240/3245 - SYNTHESISER PCB - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
C115	Not fitted				
C116	100n		63V	Ceramic Disc	Siemens B37449
C117	100n		63V	Ceramic Disc	Siemens B37449
C118	100n		63V	Ceramic Disc	Siemens B37449
C119	100n		63V	Ceramic Disc	Siemens B37449
C120	100n		63V	Ceramic Disc	Siemens B37449
C121	100n		63V	Ceramic Disc	Siemens B37449
C122	Not fitted				
C123	Not fitted				
C124	220µ		16V	Electrolytic	Dubilier CEA22016
C125	47p	10	500V	Ceramic Disc	ITT CD08/WK
IC101	DM81LS95N				National
IC102	SN74LS373N				Texas
IC103	P8253				Intel
IC104	SN74S112N				Texas
IC105	SN74LS393N				Texas
IC106	SN74LS76N				Texas
IC107	SN74LS86N				Texas
IC108	SN74LS390N				Texas
IC109	SN74LS393N				Texas
IC110	SN74LS251N				Texas
IC111	SN74LS00N				Texas
IC112	CD4040BE				R.C.A.
IC113	SN74LS161AN				Texas
IC114	SN74198N				Texas
IC115	SN74LS26N				Texas
IC116	SN74LS02N				Texas
IC117	SN74LS05N				Texas
IC118	SN74LS266N				Texas
IC119	SN74LS86N				Texas
IC120	SN74LS74AN				Texas
IC121	SN74LS74AN				Texas
IC122	SN74LS74AN				Texas
IC123	SN74LS74AN				Texas
IC124	SN74LS260N				Texas
IC125	SN74LS02N				Texas
IC126	SN74LS04N				Texas
IC127	SN74LS38N				Texas
IC128	Not fitted				
IC129	Not fitted				
IC130	LF357N				National
IC131	µA78-05-UC				Fairchild
IC132	38.4MHz	±0.01%		Crystal Oscillator	MF Electronics M1100
IC133	SN74S74N				Texas
IC134	SN74LS245N				Texas
IC135*	SN74LS00N				Texas
D101	1N4148			Diode	I.R.
D102	1N4148			Diode	I.R.
PL101	64-way Indirect male connector				Vero 17-2876D

* Not fitted on MkI Synthesiser boards.

6.2 3240/3245 - POWER SUPPLY PCB

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R701	120R	0.5	100ppm	Metal Film	Allen Bradley FC55
R702	348R	0.5	100ppm	Metal Film	Allen Bradley FC55
R703	100R	0.5	100ppm	Metal Film	Allen Bradley FC55
R704	1k1	0.5	100ppm	Metal Film	Allen Bradley FC55
R705	120R	0.5	100ppm	Metal Film	Allen Bradley FC55
R706	1k0	0.5	100ppm	Metal Film	Allen Bradley FC55
R707	1k1	0.5	100ppm	Metal Film	Allen Bradley FC55
R708	100R	0.5	100ppm	Metal Film	Allen Bradley FC55
R709	33R	2		Metal Oxide	Welwyn MR4
R710	12R	5	AOT	Film	Mullard SFR25
"	33R	5	AOT	Film	Mullard SFR25
"	47R	5	AOT	Film	Mullard SFR25
"	56R	5	AOT	Film	Mullard SFR25
C705	220µF		16V	Electrolytic	Mullard 03555221
C706	220µF		16V	Electrolytic	Mullard 03555221
C707	220µF		16V	Electrolytic	Mullard 03555221
C708	220µF		16V	Electrolytic	Mullard 03555221
C709	220µF		16V	Electrolytic	Mullard 03555221
C710	33µF		16V	Electrolytic	Mullard 03555339
C711	33µF		16V	Electrolytic	Mullard 03555339
C712	33µF		16V	Electrolytic	Mullard 03555339
C713	330n	20	100V	Polyester	Wima MKS4
C714	330n	20	100V	Polyester	Wima MKS4
C715	330n	20	100V	Polyester	Wima MKS4
IC701	LM350K				National
IC702	LM350K				National
IC703	LM317T				National
IC704	LM337T				National
D701	VHE 605			Diode	Varo
D702	VHE 605			Diode	Varo
D703	VHE 605			Diode	Varo
D704	VHE 605			Diode	Varo
D705	30S1			Diode	I.R.
D706	30S1			Diode	I.R.
D707	30S1			Diode	I.R.
D708	30S1			Diode	I.R.
D709	60S15			Diode	I.R.
D710	60S15			Diode	I.R.
D711	60S15			Diode	I.R.
D712	60S15			Diode	I.R.
D713	1KAB10		Block Rectifier		I.R.
D714	1N4002			Diode	Mullard
D715	1N4002			Diode	Mullard
D716	1N4002			Diode	Mullard
D717	1N4002			Diode	Mullard

(3240/3245 - POWER SUPPLY PCB - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
D718	1N4002			Diode	Mullard
D719	1N4002			Diode	Mullard
D720	1N4002			Diode	Mullard
D721	1N4002			Diode	Mullard
FS701	5 x 20 mm Fuse Holder			5AT	Belling-Lee L2080A

6.3 3240/3245 - SIGNAL SOURCE PCB

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R501	2k0	2		Metal Oxide	Welwyn MR4
R502	1k8	2		Metal Oxide	Welwyn MR4
R503	1k	5		Film	Mullard SFR25
R504	1k	5		Film	Mullard SFR25
R505	1k5	2		Metal Oxide	Welwyn MR4
R506	2k0	10		Ceramic	Allen Bradley E4A
R507	3k3	0.25	50ppm	Metal Film	Allen Bradley FC55
R508	825R	0.25	50ppm	Metal Film	Allen Bradley FC55
R509	4k7	5		Film	Mullard SFR25
R510	4k7	5		Film	Mullard SFR25
R511	4k7	5		Film	Mullard SFR25
R512	4k7	5		Film	Mullard SFR25
R513	3k3	0.25	50ppm	Metal Film	Allen Bradley FC55
R514	3k3	0.25	50ppm	Metal Film	Allen Bradley FC55
R515	2k21	0.1	25ppm	Metal Film	Allen Bradley FC55
R516	2k21	0.1	25ppm	Metal Film	Allen Bradley FC55
R517	1k65	0.1	25ppm	Metal Film	Allen Bradley FC55
R518	1k65	0.1	25ppm	Metal Film	Allen Bradley FC55
R519	1k74	1	100ppm	Metal Film	Allen Bradley FC55
R520	1k74	1	100ppm	Metal Film	Allen Bradley FC55
R521	5k11	1	100ppm	Metal Film	Allen Bradley FC55
R522	5k11	1	100ppm	Metal Film	Allen Bradley FC55
R523	18k7	1	100ppm	Metal Film	Allen Bradley FC55
R524	18k7	1	100ppm	Metal Film	Allen Bradley FC55
R525	28k	1	100ppm	Metal Film	Allen Bradley FC55
R526	28k	1	100ppm	Metal Film	Allen Bradley FC55
R527	Not fitted				
R528	Not fitted				
R529	3k0	1	100ppm	Metal Film	Allen Bradley FC55
R530	100k	5		Film	Mullard SFR25
R531	100k	5		Film	Mullard SFR25
R532	150R	10		Wire Wound	Welwyn W21
R533	7k5	1	100ppm	Metal Film	Allen Bradley FC55
R534	1k2	2		Metal Oxide	Welwyn MR4
R535	270R	2		Metal Oxide	Welwyn MR4
R536	680R	5		Film	Mullard SFR25
R537	33k	2		Metal Oxide	Welwyn MR4
R538	33k	2		Metal Oxide	Welwyn MR4
R539	3k3	2		Metal Oxide	Welwyn MR4
R540	100R	5		Film	Mullard SFR25
R541	2k0	2		Metal Oxide	Welwyn MR4
R542	2k0	10		Ceramic	Allen Bradley E4A
R543	1k0	2		Metal Oxide	Welwyn MR4
R544	Not fitted				
R545	12k	5		Film	Mullard SFR25
R546	22R	5		Film	Mullard SFR25
R547	22R	5		Film	Mullard SFR25
R548	Not fitted				
R549	Not fitted				
R550	Not fitted				
R551	Not fitted				
R552	1k5	5		Film	Mullard SFR25
R553	1k5	5		Film	Mullard SFR25

(3240/3245 - SIGNAL SOURCE PCB - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R554	1R8	5		Film	Mullard SFR25H
R555	1R8	5		Film	Mullard SFR25H
R556	100R	5		Film	Mullard SFR25
R557	100R	5		Film	Mullard SFR25
R558	47R	1		Wire Wound	Welwyn W21
R559	1R0	5		Film	Mullard SFR25
R560	1R8	5		Film	Mullard SFR25
R561	Not fitted				
R562	360R	1	100ppm	Metal Film	Allen Bradley FC55
R563	383R	1	100ppm	Metal Film	Allen Bradley FC55
R564	4R99	1	100ppm	Metal Film	Holsworthy H8
R565	1k	5		Film	Mullard SFR25
R566	12k	5		Film	Mullard SFR25
R567	4k7	5		Film	Mullard SFR25
R568	4k7	5		Film	Mullard SFR25
R569	1k3	2		Metal Oxide	Welwyn MR4
R570	8R2	5		Film	Mullard SFR25H
R571	8R2	5		Film	Mullard SFR25H
R572	Not fitted				
R573	Not fitted				
R574	2R2	5		Film	Mullard SFR25H
R575	2R2	5		Film	Mullard SFR25H
R576	Not fitted				
R577	10R	5		Film	Mullard SFR25
R578	Not fitted				
R579	4k7	5		Film	Mullard SFR25
R580	4R7	5		Film	Mullard SFR25
C501	33p	1p	160V	Polystyrene	Suflex HS
C502	100µ		10V	Electrolytic	Mullard 035-54101
C503	100µ		10V	Electrolytic	Mullard 035-54101
C504	56p	2.5	160V	Polystyrene	LCR FSC
C505	10µ		50V	Electrolytic	Mullard 035-90008
C506	33p	1p	160V	Polystyrene	Suflex HS
C507	36p	1p AOT	160V	Polystyrene	Suflex HS
"	33p	1p AOT	160V	Polystyrene	Suflex HS
"	39p	1p AOT	160V	Polystyrene	Suflex HS
C508	100n		63V	Ceramic	Siemens B37449
C509	Not fitted				
C510	4n04	1	63V	Polycarbonate	MFD OPR4n04F63
C511	4n04	1	63V	Polycarbonate	MFD OPR4n04F63
C512	165n	1	63V	Polycarbonate	MFD OPR165nF63
C513	165n	1	63V	Polycarbonate	MFD OPR165nF63
C514	100p	1	160V	Polystyrene	LCR FSC
C515	100p	1	160V	Polystyrene	LCR FSC
C516	2n2	2.5	160V	Polystyrene	LCR FSC
C517	Not fitted				
C518	Not fitted				
C519	220µ		16V	Electrolytic	Mullard 035-55221
C520	220µ		16V	Electrolytic	Mullard 035-55221
C521	10p	10	500V	Ceramic	ITT CD08/KCG

(3240/3245 - SIGNAL SOURCE PCB - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
C522	100n		63V	Ceramic	Siemens B37449
C523	100n		63V	Ceramic	Siemens B37449
C524	2200µ		40V	Electrolytic	ECC SMVB
C525	2200µ		40V	Electrolytic	ECC SMVB
C526	2200µ		40V	Electrolytic	ECC SMVB
C527	2200µ		40V	Electrolytic	ECC SMVB
C528	2200µ		40V	Electrolytic	ECC SMVB
C529-C533	Not fitted				
C534	15p	10	500V	Ceramic	ITT CD08/KCG
C535	15n	20	400V	Polyester	Wima MKS4
C536	100n		63V	Ceramic	Siemens B37449
C537	100n		63V	Ceramic	Siemens B37449
C538	Not fitted				
C539	100n		63V	Ceramic	Siemens B37449
C540	100n		63V	Ceramic	Siemens B37449
C541	100n		63V	Ceramic	Siemens B37449
C542	100n		63V	Ceramic	Siemens B37449
C543	100n		63V	Ceramic	Siemens B37449
C544	47µ		25V	Electrolytic	Mullard 035-56479
C545	47µ		25V	Electrolytic	Mullard 035-56479
IC501	SN74LS273N				Texas
IC502	SN74LS273N				Texas
IC503	AD DAC-08ED				Analog Devices
IC504	CD4052BE				RCA*
IC505	LF412				National
IC506	LF351N				National
IC507	LF412				National
IC508	SN74LS26N				Texas
IC509	CD4052BE				RCA*
D501	1N4148			Diode	I.R.
D502	Not fitted				
D503	1N4148			Diode	I.R.
D504	1N4148			Diode	I.R.
D505	Not fitted				
D506	Not fitted				
D507	1N4148			Diode	I.R.
D508	Not fitted				
D509	Not fitted				
D510	1N4002			Diode	I.R.
D511	1N4002			Diode	I.R.
D512	BZX70-C12			Zener Diode	Mullard
D513	BZX70-C12			Zener Diode	Mullard
D514	BZX79-C12			Zener Diode	Mullard
D515	1N4002			Diode	I.R.
D516	BZX79 C3V3			Zener Diode	Mullard
D517	BZX79 C12			Zener Diode	Mullard
D518	1N4148			Diode	I.R.
D519	1N4148			Diode	I.R.

* Only alternatives: SGS or National

(3240/3245 - SIGNAL SOURCE PCB - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
D520	1N4148			Diode	I.R.
D521	BZX79 C5V6			Zener Diode	Mullard
TR501	BC184			Transistor	Texas
TR502	BC184			Transistor	Texas
TR503	BC212			Transistor	Texas
TR504	BC182			Transistor	Texas
TR505	BC182			Transistor	Texas
TR506	BD229			Transistor	Mullard
TR507	BD228			Transistor	Mullard
TR508	BC212			Transistor	Texas
TR509	BC182			Transistor	Texas
TR510	BC214			Transistor	Texas
TR511	BC214			Transistor	Texas
TR512	BC184			Transistor	Texas
TR513	BC212			Transistor	Texas
TR514	BC214			Transistor	Texas
TR515	BC182			Transistor	Texas
PL501	64-way Indirect male connector				Vero 17-2876D
RL501	DIL Relay E2A5VD				ERG
RL502	DIL Relay E2A5VD				ERG
RL503	24V Relay G2R-217 PV				Omron
RL504	Not fitted				
RL505	24V Relay G2R-217 PV				Omron
RL506	DIL Relay E1A5VD				ERG

6.4 3240/3245 - INTERNAL BIAS CURRENT

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R601	30k	0.5	50ppm	Metal Film	Allen Bradley FC55
R602	10k	0.5	50ppm	Metal Film	Allen Bradley FC55
R603	10k	0.5	50ppm	Metal Film	Allen Bradley FC55
R604	22k	5		Film	Mullard SFR25
R605	330R	5		Film	Mullard SFR25
R606	10k	5		Film	Mullard SFR25
R607	10k	5		Film	Mullard SFR25
R608	3k9	1	100ppm	Metal Film	Allen Bradley FC55
R609	2k0			Cermet	Allen Bradley E4A
R610	1k0	5		Film	Mullard SFR25
R611	1k0	5		Film	Mullard SFR25
R612	100k	1	100ppm	Metal Film	Allen Bradley FC55
R613	200k			Cermet	Allen Bradley E4A
R614	220k	5		Film	Mullard SFR25
R615	3k3	1	100ppm	Metal Film	Allen Bradley FC55
R616	110k	1	100ppm	Metal Film	Allen Bradley FC55
R617	10k	5		Film	Mullard SFR25
R618	10k	5		Film	Mullard SFR25
R619	4k7	5		Film	Mullard SFR25
R620	2k2	5		Film	Mullard SFR25
R621	Not fitted				
R622	47k	5		Film	Mullard SFR25
R623	1k0	5		Film	Mullard SFR25
R624	15k	5		Film	Mullard SFR25
R625	15k	5		Film	Mullard SFR25
R626	4k7	5		Film	Mullard SFR25
R627	100k	5		Film	Mullard SFR25
R628	12R	5		Film	Mullard SFR25
R629	47R	5		Film	Mullard SFR25
R630	470R	5		Film	Mullard SFR25
R631	1k0	5		Film	Mullard SFR25
R632	6k8	5		Film	Mullard SFR25
R633	150R	5		Film	Mullard SFR25
R634	150R	5		Film	Mullard SFR25
R635	1R0	1	2.5W	Wire Wound	Welwyn W21
R636	1R0	1	2.5W	Wire Wound	Welwyn W21
R637	100k	5		Film	Mullard SFR25
R638	100k	5		Film	Mullard SFR25
R639	1k0	5		Film	Mullard SFR25
R640	10R	1	2.5W	Wire Wound	Welwyn W21
R641	150R	5		Film	Mullard SFR25
R642	470k	0.5	50ppm	Metal Film	Allen Bradley FC55
R643	470k	0.5	50ppm	Metal Film	Allen Bradley FC55
R644	470k	0.5	50ppm	Metal Film	Allen Bradley FC55
R645	100k	5		Film	Mullard SFR25
R646	470k	0.5	50ppm	Metal Film	Allen Bradley FC55
R647	3k3	5		Film	Mullard SFR25
R648	5k1	1	100ppm	Metal Film	Allen Bradley FC55
R649	100k	5		Film	Mullard SFR25
R650	680k	1	100ppm	Metal Film	Allen Bradley FC55
R651	1k0	5		Film	Mullard SFR25
R652	1k0	5		Film	Mullard SFR25
R653	10k	5		Film	Mullard SFR25

(3240/3245 - INTERNAL BIAS CURRENT - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R654	15k	5		Film	Mullard SFR25
R655	470k	5		Film	Mullard SFR25
R656	150k	5		Film	Mullard SFR25
R657	56k	5		Film	Mullard SFR25
R658	10k	5		Film	Mullard SFR25
R659	1k2	5		Film	Mullard SFR25
R660	220k	5		Film	Mullard SFR25
R661	10k	5		Film	Mullard SFR25
R662	22k	5		Film	Mullard SFR25
R663	12k	5		Film	Mullard SFR25
R664	1k2	5		Film	Mullard SFR25
R665	100k	5		Film	Mullard SFR25
R666	68k	5		Film	Mullard SFR25
R667	20k			Cermet	Allen Bradley E4A
R668	10k	5		Film	Mullard SFR25
R669	6k8	5		Film	Mullard SFR25
R670	3k3	5		Film	Mullard SFR25
R671	15k	5		Film	Mullard SFR25
R672	100R	5		Film	Mullard SFR25
R673	100R	5		Film	Mullard SFR25
R674	15k	5		Film	Mullard SFR25
R675	68k	5		Film	Mullard SFR25
R676	68k	5		Film	Mullard SFR25
R677	10k	5		Film	Mullard SFR25
R678	10k	5		Film	Mullard SFR25
R679	10k	5		Film	Mullard SFR25
R680	3k3	5		Film	Mullard SFR25
R681	6k8	5		Film	Mullard SFR25
R682	4R7	5		Film	Mullard SFR25
R683	4k7	5		Film	Mullard SFR25
R684	1k0	5		Film	Mullard SFR25H
C601	100n		63V	Ceramic	Siemens B37449
C602	1µ0	10	100V	Polyester	Wima MKS4
C603	220p	20	500V	Ceramic	ITT CD08/K1
C604	100n		63V	Ceramic	Siemens B37449
C605	100µ		10V	Electrolytic	Mullard 035-54101
C606	220µ		16V	Electrolytic	Mullard 03555221
C607	1µ0	10	100V	Polyester	Wima MKS4
C608	100n		63V	Ceramic	Siemens B37449
C609	10µ			Electrolytic	Mullard 035-90008
C610	10µ			Electrolytic	Mullard 035-90008
C611	1µ0		100V	Polyester	Wima MKS4
C612	100n	10	100V	Polyester	Wima MKS4
C613	100n		63V	Ceramic	Siemens B37449
C614	100n		63V	Ceramic	Siemens B37449
C615	100n		63V	Ceramic	Siemens B37449
C616	100n		63V	Ceramic	Siemens B37449
C617	100n		63V	Ceramic	Siemens B37449
C618	100n		63V	Ceramic	Siemens B37449
C619	220µ		16V	Electrolytic	Mullard 03555221
C620	100n		63V	Ceramic	Siemens B37449
C621	22p	10	500V	Ceramic	ITT CD08/TH

(3240/3245 - INTERNAL BIAS CURRENT - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
IC601	SN74LS175N				Texas
IC602	SN74LS273N				Texas
IC603	CD4052BE				RCA*
IC604	AD-DAC-08-ED				Analog Devices
IC605	LF351N				National
IC606	LF412CN				National
IC607	LM301AN				National
IC608	CD4053BE				RCA*
IC609	LF353N				National
IC610	LM311N				National
IC611	LF353N				National
IC612	LM339N				National
IC613	SN74LS32N				Texas
IC614	µA7805 UC				Fairchild
D602	1N4002		100V	Diode	Mullard
D603	1N4002		100V	Diode	Mullard
D604	BZX79 C3V9			Zener Diode	Mullard
D605	1N4148			Diode	Mullard
D606	1N4148			Diode	Mullard
D607	1N4148			Diode	Mullard
D608	1N4148			Diode	Mullard
D609	1N4002		100V	Diode	Mullard
D610	1N4002		100V	Diode	Mullard
D611	1N4148			Diode	Mullard
D612	BZX79C-27			Zener Diode	Mullard
D613	BZX79C-5V1			Zener Diode	Mullard
D614	1N4148			Diode	Mullard
TR601	BC182		npn	Transistor	Texas
TR602	BC214		pnp	Transistor	Texas
TR603	BC214		pnp	Transistor	Texas
TR604	BC182		npn	Transistor	Texas
TR605	BC212		pnp	Transistor	Texas
TR606	BC184		npn	Transistor	Texas
TR607	TIP36A		pnp	Transistor	Texas
TR608	BD228		npn	Transistor	Mullard
TR609	BC182		npn	Transistor	Texas
TR610	BD228		npn	Transistor	Mullard
TR611	BC184		npn	Transistor	Texas
TR612	BC214		pnp	Transistor	Texas
TR613	BC182		npn	Transistor	Texas
PL602	2-way Wafer		10-08-1021		Molex
SK702	3-way Housing 3011		10-13-1034		Molex

* Only alternative: National

6.5 3240/3245 - BRIDGE PCB

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R804	100R	5		Film	Mullard SFR25
R805	100R	5		Wire Wound	Welwyn W21
R810	1k2	2		Metal Oxide	Electrosil TR4
R811	1k0	10		Cermet	A. Bradley E4A/02
R812	3M3	5		Metal Glaze	Mullard VR25
R813	3M3	5		Metal Glaze	Mullard VR25
R814	4k7	5		Film	Mullard SFR25
R815	4k7	5		Film	Mullard SFR25
R816	4k7	5		Film	Mullard SFR25
R817	4k7	5		Film	Mullard SFR25
R818	150R	5		Film	Mullard SFR25
R819	150R	5		Film	Mullard SFR25
R820	150R	5		Film	Mullard SFR25
R821	Not fitted				
R822	5k12	.01		Metal Film	Vishay S102J
R823	640R	.01		Metal Film	Vishay S102J
R824	10R	.04		Metal Film	Vishay S102J
R825	22k	5		Film	Mullard SFR25
R826	47R	5		Film	Mullard SFR25
R827	6k2	0.5	50ppm	Metal Film	Allen Bradley FC55
R828	680k	0.5	50ppm	Metal Film	Allen Bradley FC55
R829	10k	5		Film	Mullard SFR25
R830	30k	1	50ppm	Metal Film	Allen Bradley FC55
R831	330R	0.25	50ppm	Metal Film	Allen Bradley FC55
R832	300R	5		Film	Mullard SFR25
R833	270R	0.25	50ppm	Metal Film	Allen Bradley FC55
R834	560R	5		Film	Mullard SFR25
R835	210R	0.25	50ppm	Metal Film	Allen Bradley FC55
R836	750R	5		Film	Mullard SFR25
R837	270R	0.25	50ppm	Metal Film	Allen Bradley FC55
R838	4k7	5		Film	Mullard SFR25
R839	3M3	5		Metal Glaze	Mullard VR25
R840	3M3	5		Metal Glaze	Mullard VR25
R841	3M3	5		Metal Glaze	Mullard VR25
R842	3M3	5		Metal Glaze	Mullard VR25
R843	4k3	5		Film	Mullard SFR25
R844	100R	5		Film	Mullard SFR25
R845	2k0	10		Cermet	A.Bradley E4A202
R846	100k	5		Film	Mullard SFR25
R847	15R	5		Film	Mullard SFR25
R848	15R	5		Film	Mullard SFR25
R849	100R	5		Film	Mullard SFR25
R850	22k	5		Film	Mullard SFR25
R851	150R	5		Film	Mullard SFR25H
R852	150R	5		Film	Mullard SFR25H
R853	10k	5		Film	Mullard SFR25
R854	10k	5		Film	Mullard SFR25
R855	10k	5		Film	Mullard SFR25
R856	1k05	0.25	50ppm	Metal Film	Allen Bradley FC55
R857	150R	0.25	50ppm	Metal Film	Allen Bradley FC55
R858	49R9	0.25	50ppm	Metal Film	Allen Bradley FC55
R859	180R	5		Film	Mullard SFR25
R860	120R	5		Film	Mullard SFR25

(3240/3245 - BRIDGE PCB - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R861	4k7			SIL N/W	Hitech L109
R862	470R	0.25	50ppm	Metal Film	Allen Bradley FC55
R863	470R	0.25	50ppm	Metal Film	Allen Bradley FC55
R864	470R	0.25	50ppm	Metal Film	Allen Bradley FC55
R865	470R	0.25	50ppm	Metal Film	Allen Bradley FC55
R866	8k2	1	50ppm	Metal Film	Allen Bradley FC55
R867	2R0	1		Wire Wound	Welwyn W22
R868	22R	5		Film	Mullard SFR25
R869	100R	5		Film	Mullard SFR25
R870	100R	5		Film	Mullard SFR25
R871	100R	5		Film	Mullard SFR25
R872	100R	5		Film	Mullard SFR25
R873	1k2	5		Film	Mullard SFR25
R874	20k	10		Cermet	A. Bradley E4A203
R875	1k3	2		Metal Oxide	Electrosil TR4
R876	2k0	2		Metal Oxide	Electrosil TR4
R877	390k	1	50ppm	Metal Film	Allen Bradley FC55
R878	130k	2		Metal Oxide	Electrosil TR4
R879	33k	1	50ppm	Metal Film	Allen Bradley FC55
R880	22k	2		Metal Oxide	Electrosil TR4
R881	6k2	2		Metal Oxide	Electrosil TR4
R882	2k7	5		Film	Mullard SFR25
R883	10R	5		Film	Mullard SFR25
R884	1k5	2		Metal Oxide	Electrosil TR4
R885	4M7	10		Film	Mullard SFR25
R886	2M2	10		Film	Mullard SFR25
R887	4M7	10		Film	Mullard SFR25
R888	2M2	10		Film	Mullard SFR25
R889	27k	5		Film	Mullard SFR25
R890	62k	5		Film	Mullard SFR25
R891	47k	5		Film	Mullard SFR25
R892	10k	5		Film	Mullard SFR25
R893	8R2	5		Film	Mullard SFR25H
R894	8R2	5		Film	Mullard SFR25H
C803	100µ		10V	Electrolytic	Mullard 03554101
C804	47µ		10V	Electrolytic	Mullard 03554479
C805	2.2µ	20	63V	Polyester	Wima MKS4
C806	2.2µ	20	63V	Polyester	Wima MKS4
C807	330p	2.5	160V	Polystyrene	LCR FSC
C808	Not fitted				
C809	Not fitted				
C810	470n	5	400V	Polyester	Wima MKS4
C811	470n	5	400V	Polyester	Wima MKS4
C812	470n	5	100V	Polyester	Wima MKS4
C813	470n	5	100V	Polyester	Wima MSK4
C814	470n	5	100V	Polyester	Wima MKS4
C815	470n	5	100V	Polyester	Wima MKS4
C816	82p	1p	160V	Polystyrene	Suflex HS
C817	4n7	2.5	160V	Polystyrene	LCR FSC
C818	1n0	2.5	160V	Polystyrene	LCR FSC
C819	100n		63V	Ceramic	Siemens B37449
C820	100n		63V	Ceramic	Siemens B37449

(3240/3245 - BRIDGE PCB - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
C821	10p	5	500V	Ceramic	Thompson CSF GLC604
C822	220n	20	100V	Polyester	Wima MKS4
C823	Not fitted				
C824	100n		63V	Ceramic	Siemens B37449
C825	100n		63V	Ceramic	Siemens B37449
C826	1µ		100V	Electrolytic	Mullard 03559108
C827	1µ		100V	Electrolytic	Mullard 03559108
C828	Not fitted				
C829	220µ		16V	Electrolytic	Mullard 03555221
C830	220µ		16V	Electrolytic	Mullard 03555221
C831	4p7	0.5p	500V	Ceramic	ITT CD08/DAG
C832	4p7	0.5p	500V	Ceramic	ITT CD08/DAG
C833	470p	20	500V	Ceramic	ITT CD08/MK1
C834	68p	2.5	160V	Polystyrene	LCR FSC
C835	100n		63V	Ceramic	Siemens B37449
C836	100n		63V	Ceramic	Siemens B37449
C837	100n		63V	Ceramic	Siemens B37449
C838	47µ		25V	Electrolytic	Mullard 03556479
C839	100n		63V	Ceramic	Siemens B37449
C840	47µ		25V	Electrolytic	Mullard 03556479
C841	47µ		25V	Electrolytic	Mullard 03556479
C842	47µ		25V	Electrolytic	Mullard 03556479
C843	Not fitted				
C844	2-10p			TET Hor.Mtg.	Jackson Br. 5750HPC
C845	Not fitted				
C846	100n		63V	Ceramic	Siemens B37449
C847	100n		63V	Ceramic	Siemens B37449
C848	100n		63V	Ceramic	Siemens B37449
C849	5p	1p	160V	Polystyrene	Suflex HS
IC801	TL070CP				Texas
IC802	CD4052BE				RCA*
IC803	CD4053BE				RCA*
IC804	CD4052BE				RCA*
IC805	TL072CP				Texas
IC806	NE5534N				Signetics
IC807	SN74LS26N				Texas
IC808	SN74LS26N				Texas
IC809	SN74LS26N				Texas
IC810	SN74LS273N				Texas
IC811	SN74LS273N				Texas
IC812	CD4052BE				RCA*
IC813	LM733CN				National
IC814	TL071CP				Texas
IC815	CD4052BE				RCA*
IC816	TL070CP				Texas
IC817	LM339N				National
D801	1N4006			Diode	I.R.
D802	1N4006			Diode	I.R.
D803	1N4148			Diode	I.R.
D804	1N4148			Diode	I.R.

* Only alternatives: SGS, National

(3240/3245 - BRIDGE PCB - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
D805	1N4006			Diode	I.R
D806	1N4006			Diode	I.R
D807	1N4006			Diode	I.R.
D808	1N4148			Diode	I.R.
D809	BZX79 C3V6			Diode	Mullard
D810	1N4148			Diode	I.R.
D811	BZX79 C3V6			Diode	Mullard
D812	1N4148			Diode	I.R.
D813	BZX79 C7V5			Diode	Mullard
D814	BZX79 C7V5			Diode	Mullard
D815	1N4006			Diode	I.R.
D816	1N4006			Diode	I.R.
D817	1N4006			Diode	I.R.
D818	1N4006			Diode	I.R.
D819	1N4006			Diode	I.R.
D820	Not fitted				
D821	Not fitted				
D822	1N4006			Diode	I.R.
D823	1N4006			Diode	I.R.
D824	1N4006			Diode	I.R.
D825	1N4006			Diode	I.R.
D826	1N4006			Diode	I.R.
D827	1N4148			Diode	I.R.
D828	1N4006			Diode	I.R.
D829	1N4006			Diode	I.R.
TR801	BC212			Transistor	Texas
TR802	BC214			Transistor	Texas
TR803	BC182			Transistor	Texas
TR804	BC212			Transistor	Texas
TR805	BD229			Transistor	Mullard
TR806	BD228			Transistor	Mullard
TR807	Not fitted				
TR808	BC212			Transistor	Texas
TR809	BC184C			Transistor	Texas
TR810	BC184			Transistor	Texas
TR811	BC214			Transistor	Texas
TR812	J113			Transistor	Siliconix
TR813	J113			Transistor	Siliconix
FS801	Fuse	20x5mm	1.6A		B.Lee L1427B
L801	Screening Beads		Fx1115		Mullard
L802	Screening Beads		Fx1115		Mullard
PL801	64-way Indirect male connector				Vero 17-2876D
RL801	Relay DIL E-1A-5V-D				ERG
RL802	Relay DIL E-1A-5V-D				ERG
RL803	Relay DIL E-1A-5V-D				ERG
RL804	Relay DIL E-1A-5V-D				ERG
TP01	Terminal Assy				Vero 20-2137D
TP02	Terminal Assy				Vero 20-2137D

6.6 3240/3245 - DETECTOR PCB

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R901	700R	0.005		Film	Vishay S102J
R902	100R	0.005		Film	Vishay S102J
R903	91R	1	100ppm	Metal Film	Allen Bradley FC55
R904	3k4	1	100ppm	Metal Film	Allen Bradley FC55
R905	390R	1	100ppm	Metal Film	Allen Bradley FC55
R906	348R	1	100ppm	Metal Film	Allen Bradley FC55
R907	3k09	1	100ppm	Metal Film	Allen Bradley FC55
R908	887R	1	100ppm	Metal Film	Allen Bradley FC55
R909	680R	5		Film	Mullard SFR25
R910	2k4	0.1	25ppm	Metal Film	Allen Bradley FC55
R911	2k4	0.1	25ppm	Metal Film	Allen Bradley FC55
R912	2k2	0.1	25ppm	Metal Film	Allen Bradley FC55
R913	2k2	0.1	25ppm	Metal Film	Allen Bradley FC55
R914	3k74	1	100ppm	Metal Film	Allen Bradley FC55
R915	3k74	1	100ppm	Metal Film	Allen Bradley FC55
R916	10k7	1	100ppm	Metal Film	Allen Bradley FC55
R917	10k7	1	100ppm	Metal Film	Allen Bradley FC55
R918	38k3	1	100ppm	Metal Film	Allen Bradley FC55
R919	38k3	1	100ppm	Metal Film	Allen Bradley FC55
R920	57k6	1	100ppm	Metal Film	Allen Bradley FC55
R921	57k6	1	100ppm	Metal Film	Allen Bradley FC55
R922	330R	5		Film	Mullard SFR25
R923	330R	5		Film	Mullard SFR25
R924	4k7	2		SIL N/W	Hitech L109
R925	2R2	5		Film	Mullard SFR25H
R926	2R2	5		Film	Mullard SFR25H
R927	4k7	2		Metal Oxide	Welwyn MR4
R928	4k7	2		Metal Oxide	Welwyn MR4
R929	100k	5		Film	Mullard SFR25
R930	100k	5		Film	Mullard SFR25
R931	1k0	2		SIL N/W	Hitech L109
R932	1k0	2		SIL N/W	Hitech L109
R933	10k	5		Film	Mullard SFR25
R934	Not fitted				
R935	3k9	5		Film	Mullard SFR25
R936	Not fitted				
R937	1k5	5		Film	Mullard SFR25
R938	3k6	1	100ppm	Metal Film	Allen Bradley FC55
R939	1k5	1	100ppm	Metal Film	Allen Bradley FC55
R940	10k	5		Film	Mullard SFR25
R941	18k	2		Metal Oxide	Welwyn MR4
R942	22k	2		Metal Oxide	Welwyn MR4
R943	33k	5		Film	Mullard SFR25
R944	10k	5		Film	Mullard SFR25
R945	Not fitted				
R946	47k	0.25	50ppm	Metal Film	Allen Bradley FC55
R947	30k	0.25	50ppm	Metal Film	Allen Bradley FC55
R948	51k	0.25	50ppm	Metal Film	Allen Bradley FC55
R949	64k9	0.25	50ppm	Metal Film	Allen Bradley FC55
R950	12k7	1	100ppm	Metal Film	Allen Bradley FC55
R951	330R	5		Film	Mullard SFR25
R952	20k	0.5	50ppm	Metal Film	Allen Bradley FC55
R953	Not fitted				
R954	8k25	0.5	50ppm	Metal Film	Allen Bradley FC55

(3240/3245 - DETECTOR PCB - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R955	3k3	5		Film	Mullard SFR25
R956	6k2	5		Film	Mullard SFR25
R957	1k3	2		Metal Oxide	Welwyn MR4
R958	1k5	2		Metal Oxide	Welwyn MR4
R967	1k8	1	100ppm	Metal Film	Allen Bradley FC55
R968	3k3	1	100ppm	Metal Film	Allen Bradley FC55
R969	1k	5		Film	Mullard SFR25
C901	47µF		25V	Electrolytic	Mullard 035/56479
C902	47µF		25V	Electrolytic	Mullard 035/56479
C903	470µF		16V	Electrolytic	Mullard 035/55471
C904	470µF		16V	Electrolytic	Mullard 035/55471
C905	470µF		16V	Electrolytic	Mullard 035/55471
C906	330n	10	100V	Polyester	Wima MKS4
C907	56p	1p	160V	Polystyrene	Sulfex HS
C908	91p	1p	160V	Polystyrene	Suflex HS
C909	91p	1p	160V	Polystyrene	Suflex HS
C910	4n04	1	63V	Polycarbonate	MFD OPR4n04F63
C911	4n04	1	63V	Polycarbonate	MFD OPR4n04F63
C912	165n	1	63V	Polycarbonate	MFD OPR165nF63
C913	165n	1	63V	Polycarbonate	MFD OPR165nF63
C914	1µ2	1	63V	Polycarbonate	MFD OPR1200nF63
C915	300n	1	63V	Polycarbonate	MFD OPR300nF63
C916	47n	2.5	30V	Polystyrene	LCR FSC
C917	330p	10	500V	C. Disc	Thomson CSF-G GLB604 Y5P
C918	100p	10		Ceramic Disc	ITT CD08 N3300
C919	220p	10		Ceramic Disc	ITT CD08/4700
C920	100n		63V	Ceramic Disc	Siemens B37449
C921	100n		63V	Ceramic Disc	Siemens B37449
C922	100n		63V	Ceramic Disc	Siemens B37449
C923	100n		63V	Ceramic Disc	Siemens B37449
C924	1n0	20		Ceramic Disc	ITT CD08 K2
C925	100n		63V	Ceramic Disc	Siemens B37449
C926	100n		63V	Ceramic Disc	Siemens B37449
C927	10n		40V	Ceramic Disc	ITT TD08K3
C928	4n7	10	63V	C. Disc	Roederstein ROZ 767FA
IC901	SN74LS273N				Texas
IC902	CD4053BE				RCA*
IC903	NE5534N				Signetics
IC904	LF353N				National
IC905	SN74LS26N				Texas
IC906	SN74LS26N				Texas
IC907	LF412CN				National
IC908	CD4052BE				RCA*
IC909	µA7805-UC				Fairchild
IC910	SD5001N				Signetics

* Only alternatives: National, SGS

(3240/3245 - DETECTOR PCB - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
IC911	TL072CP				Texas
IC912	DG211CJ				Siliconix
IC913	LM339N				National
IC914	LM339N				National
IC915	9495CJ				Teledyne
IC916	µA7808-UC				Fairchild
D901	1N4148			Diode	
D902	1N4148			Diode	
D905	1N4148			Diode	
D906	1N4148			Diode	
D907	1N4148			Diode	
D908	1N4148			Diode	
TP01	Terminal Assy 20-2137D				Vero
TP02	Terminal Assy 20-2137D				Vero
TP03	Termianl Assy 20-2137D				Vero
TP04	Terminal Assy 20-2137D				Vero
TR901	VN2222L		FET	Transistor	Siliconix
TR902	VN2222L		FET	Transistor	Siliconix
TR903	VN2222L		FET	Transistor	Siliconix
TR904	VN2222L		FET	Transistor	Siliconix
TR905	J113		FET	Transistor	Siliconix
PL900	64-way Indirect Male Connector				Vero 17-2876D
RL901	Relay DIL E-2A-5V-D				ERG
RL902	Relay DIL E-2A-5V-D				ERG

6.7 3240/3245 - MOTHER BOARD PCB

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R1001	270R	5		Film	Mullard SFR25
SK1001	64-way Indirect Connector				Panduit 100-964-433
SK1002	64-way Indirect Connector				Panduit 100-964-433
SK1003	64-way Indirect Connector				Panduit 100-964-433
SK1004	64-way Indirect Connector				Panduit 100-964-433
SK1005	64-way Indirect Connector				Panduit 100-964-433
SK1006	64-way Indirect Connector				Panduit 100-964-433

6.8 3240/3245 - CPU & TV PCB

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R300	4k7			SIL N/W	Hitech L109
R301	4k7	5		Film	Mullard SFR25
R302	100R	5		Film	Mullard SFR25
R303	1k0	5		Film	Mullard SFR25
R304	1k0	5		Film	Mullard SFR25
R305	2k2			SIL N/W	Hitech L109
R306	1k0	5		Film	Mullard SFR25
R307	560R	5		Film	Mullard SFR25
R308	470R	5		Film	Mullard SFR25
R309	470R	5		Film	Mullard SFR25
R310	1k2	5		Film	Mullard SFR25
R311	1k2	5		Film	Mullard SFR25
R312	20k			Cermet	A. Bradley E4A203
R313	39k	5		Film	Mullard SFR25
R314	1k0	5		Film	Mullard SFR25
C300	220µ		10V	Electrolytic	Mullard 031 34221
C301	1n	-20,+80	500V	Ceramic Disc	ITT CD08/K2
C302	220p	20	500V	Ceramic Disc	ITT CD08/K1
C303	220p	20	500V	Ceramic Disc	ITT CD08/K1
C304	100n		63V	Ceramic Disc	Siemens B37449
C305	100n		63V	Ceramic Disc	Siemens B37449
C306	100n		63V	Ceramic Disc	Siemens B37449
C307	100n		63V	Ceramic Disc	Siemens B37449
C308	100n		63V	Ceramic Disc	Siemens B37449
C309	100n		63V	Ceramic Disc	Siemens B37449
C310	100n		63V	Ceramic Disc	Siemens B37449
C311	100n		63V	Ceramic Disc	Siemens B37449
C312	100n		63V	Ceramic Disc	Siemens B37449
C313	100n		63V	Ceramic Disc	Siemens B37449
C314	100n		63V	Ceramic Disc	Siemens B37449
C315	100n		63V	Ceramic Disc	Siemens B37449
C316	100n		63V	Ceramic Disc	Siemens B37449
C317	100n		63V	Ceramic Disc	Siemens B37449
C318	100n		63V	Ceramic Disc	Siemens B37449
C319	100n		63V	Ceramic Disc	Siemens B37449
IC300	LM78-L12-ACZ			Regulator	National
IC301	DM81LS95N				National
IC302	SN74LS138N				Texas
IC303	SN74LS26N				Texas
IC304	LM79-L12-ACZ			Regulator	National
IC305	Z80 CPU PS				Zilog
IC306	SN74LS74AN				Texas
IC307	SN74LS245N				Texas
IC308	SN74LS244N				Texas
IC309	SN74LS244N				Texas
IC310	SN74LS244N				Texas
IC311	SN74LS09N				Texas
IC312	MC6845P				Motorola
IC313	SN74LS76N				Texas
IC314	SN74LS157N				Texas
IC315	SN74LS157N				Texas

(3240/3245 - CPU & TV PCB - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
IC316	SN74LS157N				Texas
IC317	SN74LS157N				Texas
IC318	P2114A-6				Intel
IC319	SN74LS244N				Texas
IC320	SN74LS373N				Texas
IC321	SN74LS74AN				Texas
IC322	SN74LS161AN				Texas
IC323	SN74LS166N				Texas
IC324	Programmed				WK DW4/25594
IC325	Programmed				WK DW4/25594
IC326	Not fitted				
IC327	SN74LS32N				Texas
IC328	SN74LS08N				Texas
IC329	SN74LS00N				Texas
IC330	SN74LS132N				Texas
IC331	SN74LS00N				Texas
IC332	SN74LS132N				Texas
IC333	SN74LS32N				Texas
IC334	SN74LS02N				Texas
IC335	SN74LS04N				Texas
IC336	SN74LS04N				Texas
IC337	LM311N				National
D300	1N4002			Diode	I.R.
D301	BZX79 C5V6			Diode	Mullard
TR300	2N2369A			Transistor	Mullard
PL301	64-way Indirect Male Connector				Vero 17-2876D
S300	MDP Switch 69955B				ITT

6.9 3240/3245 - KEYBOARD PCB

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
C400	100n		63V	Ceramic	Siemens B37449
IC400	SN74LS145N				Texas
S400 to S432 inc.	Switch 75-120-002		Black		Preh
SK401	Socket				Rendar R322-180.00

6.10 FRONT PANEL

D1001	LED	HLMP/3401	Hewlett Packard
PL1004	Insulated Bulkhead Connector	LX04-0503-22005N	Belling Lee
PL1005	Insulated Bulkhead Connector	LX04-0503-22005N	Belling Lee
PL1006	Insulated Bulkhead Connector	LX04-0503-22005N	Belling Lee
PL1007	Insulated Bulkhead Connector	LX04-0503-22005N	Belling Lee

6.11 KME LEAD ASSEMBLY

- Connector Lead Assembly (KME to Mother Board) To WK Drg. DV3/25649

6.12 3240/3245 - REAR PANEL

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R001	1kO	Lin.	CE8S Bush	F5 Spindle	Radiohm P20C
C001	22,000µ	Elec.	16V	071 15223	Mullard
C002	6,800µ	Elec.	40V	071 17682	Mullard
C003	10,000µ	Elec.	40V	071 17103	Mullard
C004	2,200µ	Elec.	40V	071 17222	Mullard
FS001	Fuse 1A SB 20mm			L2080A	Belling-Lee
PL001	CEE22 Appliance Inlet				Rendar R470,300.00
S001	Power Switch (inc. bracket) MU 1999 MMS				Lipa Isostat
S002	2-pole Slide Switch				Rendar R530,040.00
S003	Thermostat 5004-013-068				Airpax
SK002	Black Terminal L1568				Belling-Lee
SK003	Red Terminal L1568				Belling-Lee
T001	Transformer				WK 4-385-5570

6.13 3240/3245 - MEMORY BOARD MkII PCB

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R200	1k0	5		Film	Mullard SFR25
R201	4k7			SIL N/W	Hitech L109
R202	4k7			SIL N/W	Hitech L109
R203	4k7			SIL N/W	Hitech L109
R204	47k	5		Film	Mullard SFR25
R205	100R	5		Film	Mullard SFR25
R206	4k7	5		Film	Mullard SFR25
R207	4k7	5		Film	Mullard SFR25
R208	1k0	5		Film	Mullard SFR25
R209	1k0	5		Film	Mullard SFR25
R210	2k7	5		Film	Mullard SFR25
R211	10k	5		Film	Mullard SFR25
R212	39R	5		Film	Mullard SFR25
R227	4k7	5		Film	Mullard SFR25
R232	4k7	5		Film	Mullard SFR25
C200	10µ		25V	Electrolytic	Mullard 030 36109
C201	100n			Ceramic Disc	Siemens B37449
C202	10µ		25V	Electrolytic	Mullard 030 36109
C203	100n			Ceramic Disc	Siemens B37449
C204	Not fitted				
C205	100n			Ceramic Disc	Siemens B37449
C206	100n			Ceramic Disc	Siemens B37449
C207	100n			Ceramic Disc	Siemens B37449
C208	100n			Ceramic Disc	Siemens B37449
C209	100n			Ceramic Disc	Siemens B37449
C210	100n			Ceramic Disc	Siemens B37449
C211	100n			Ceramic Disc	Siemens B37449
C212	100n			Ceramic Disc	Siemens B37449
C213	22µ		10V	Tantalum Bead	ITT TAG 22/10V
C214	100n			Ceramic Disc	Siemens B37449
C215	100n			Ceramic Disc	Siemens B37449
C216	100n			Ceramic Disc	Siemens B37449
C217	100n			Ceramic Disc	Siemens B37449
C218	100n			Ceramic Disc	Siemens B37449
C219	47p	10	500V	Ceramic Disc	ITT CD08/WK
C220	1n0	20	500V	Ceramic Disc	ITT CD08/MK2
IC200	SN74LS245N				Texas
IC201	SN74LS09N				Texas
IC202	SN74LS09N				Texas
IC203	Programmed				WK DV4/25673 item 24
IC204	Programmed				WK DV4/25673 item 25
IC205	Programmed				WK DV4/25673 item 26
IC206	(Reserved for expansion)				
IC214	SN74LS139N				Texas
IC215	SN74LS00N				Texas
IC216	SN74LS138N				Texas
IC217	SN74LS138N				Texas
IC218	DM81LS96N				National

(3240/3245 - MEMORY BOARD MkII PCB - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
IC219	SN74LS175N				Texas
IC220	SN74LS08N				Texas
IC221	SN74LS32N				Texas
IC222	SN74LS32N				Texas
IC223	P2114A-6				Intel
IC224	P2114A-6				Intel
IC233	µPD444/6514				NEC
IC234	µPD444/6514				NEC
IC235	LM78L05ACZ				National
D200	BZX79 C3V0			Diode	Mullard
D201	1N4148			Diode	Mullard
D202	Not fitted				
D203	Not fitted				
D204	1N4148			Diode	Mullard
D205	1N4148			Diode	Mullard
D206	1N4148			Diode	Mullard
TR200	BC183			Transistor	Texas
TR201	Not fitted				
TR202	Not fitted				
TR203	BC183			Transistor	Texas
TR204	BC183			Transistor	Texas
B200	BR-2/3A-1P			Battery	National (Dubilier)
PL200	64-way Indirect Male Connector				Vero 17-2876D
PL202	64-way Indirect Male Connector				Vero 17-2876D

NOTE <u>Memory Board MkI</u>

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Circuit Diagram " 6-33

<u>Memory Board MkIII</u>

Components List Page 6-67
Circuit Diagram " 6-69

6.14 3240/3245 - MEMORY BOARD MkI PCB

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R200	1kO	5		Film	Mullard SFR25
R201	4k7			SIL N/W	Hitech 4019
R202	4k7			SIL N/W	Hitech 4019
R203	4k7			SIL N/W	Hitech 4019
R204	47k	5		SIL N/W	Hitech 4019
R205	100R			Film	Mullard SFR25
R206	4k7	5		Film	Mullard SFR25
R207	4k7	5		Film	Mullard SFR25
R208	1kO	5		Film	Mullard SFR25
R209	1kO	5		Film	Mullard SFR25
R210	2k7	5		Film	Mullard SFR25
R211	10k	5		Film	Mullard SFR25
R227	4k7	5		Film	Mullard SFR25
R232	4k7	5		Film	Mullard SFR25
C200	10µ		25V	Electrolytic	Mullard 030 36109
C201	100n			Ceramic Disc	Siemens B37449
C202	10µ		25V	Electrolytic	Mullard 030 36109
C203-C212 inc	100n			Ceramic Disc	Siemens B37449
C213	22µ		10V	Tantalum Bead	ITT TAG 22/10V
C214-C218 inc	100n			Ceramic Disc	Siemens B37449
C219	47p	10	500V	Ceramic Disc	ITT CD08/WK
IC200	SN74LS245N				Texas
IC201	SN74LS09N				Texas
IC202	SN74LS09N				Texas
IC203-IC212 inc				Programmed	WK 5-385-5513
IC213	SN74LS138N				Texas
IC214	SN74LS139N				Texas
IC215	SN74LS00N				Texas
IC216	SN74LS138N				Texas
IC217	SN74LS138N				Texas
IC218	DM81LS96N				National
IC219	SN74LS175N				Texas
IC220	SN74LS08N				Texas
IC221	SN74LS32N				Texas
IC222	SN74LS32N				Texas
IC223	P2114A-6				Intel
IC224	P2114A-6				Intel
IC233	µPD444/6514				NEC
IC234	µPD444/6514				NEC
IC235	LM78L05ACZ				National
PL200	64-way Indirect Male Connector				Vero 17-2876D
PL202	64-way Indirect Male Connector				Vero 17-2876D

6.15 3245 - G.P.I.B. & S.H.I. OPTION (N/A to 3240)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R1	4k7	2		SIL N/W	Hitech L109
R2	1kO	2		SIL N/W	Hitech L109
C1	10µ		25V		ITT TAG 10/25V
C2-C13 inc	100n		63V	Ceramic Disc	Siemens B37449
C14	220n		10V	Ceramic Disc	ITT (811T) T016
C15	220p	20		Ceramic Disc	ITT CD08/K1
IC1	MC68488P				Motorola
IC2	MC3448A				Motorola
IC3	MC3448A				Motorola
IC4	MC3448A				Motorola
IC5	MC3448A				Motorola
IC6	74LS244N				Texas
IC7	74LS245N				Texas
IC8	74LS136N				Texas
IC9	74LS02N				Texas
IC10	74LS14N				Texas
IC11	74LS05N				Texas
IC12	74LS74AN				Texas
PL1	64-way Indirect Male Connector				Vero 17-2876D
SK2	24-way Indirect Female Connector				Amphenol 57-20240/2
SW1	16-pin DIL Switch				ERG SDS8
SW2	16-pin DIL Switch				ERG SDS8

NOTE <u>Memory Board MkII</u>

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Circuit Diagram " 6-35

<u>Memory Board MkIII</u>

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Circuit Diagram " 6-69

6.16 3245 - ANALOG OUTPUT OPTION (N/A to 3240)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R1802	4k7	5		Film	Mullard SFR25
R1805	4k7	5		Film	Mullard SFR25
R1806	560R			Film	Mullard SFR25
R1807	180k	1	25ppm	Metal Film	Allen Bradley FC55
R1808	180k	1	25ppm	Metal Film	Allen Bradley FC55
R1809	22k	1	25ppm	Metal Film	Allen Bradley FC55
R1810	20k	10		Cermet	Spectrol 63XENDMT
R1811	4M7	5		Metal Glaze	Mullard VR37
R1812	10k	5		Film	Mullard SFR25
R1813	22k	1	25ppm	Metal Film	Allen Bradley FC55
R1814	10k	10		Cermet	A. Bradley E4A103
R1815	20k	10		Cermet	Spectrol 63XENDMT
R1816	4M7	5		Metal Glaze	Mullard VR37
R1817	10k	5		Film	Mullard SFR25
R1818	47R	5		Film	Mullard SFR25
R1819	47R	5		Film	Mullard SFR25
R1820	100k	1	25ppm	Metal Film	Allen Bradley FC55
R1821	100k	1	25ppm	Metal Film	Allen Bradley FC55
R1822	100k	1	25ppm	Metal Film	Allen Bradley FC55
R1823	100k	1	25ppm	Metal Film	Allen Bradley FC55
R1824	10k	10		Cermet	A. Bradley E4A103
R1825	10k	5		Film	Mullard SFR25
R1826	10R	5		Film	Mullard SFR25
R1827	10R	5		Film	Mullard SFR25
C1801	100n		63V	Ceramic Disc	Siemens B37449
C1802	100n		63V	Ceramic Disc	Siemens B37449
C1803	100n		63V	Ceramic Disc	Siemens B37449
C1804	100n		63V	Ceramic Disc	Siemens B37449
C1805	33n	5	250V	Polyester	Wima MKS4
C1806	150n	5	100V	Polyester	Wima MKS4
C1807	150n	5	100V	Polyester	Wima MKS4
C1808	33n	5	250V	Polyester	Wima MKS4
C1809	10µ		25V	Tantalum Bead	ITT/STC TAG10/25V
C1810	10µ		25V	Tantalum Bead	ITT/STC TAG10/25V
C1811	68n	5	250V	Polyester	Wima MKS4
C1812	68n	5	250V	Polyester	Wima MKS4
C1813	220n		10V	C. Disc, Transcap	ITT/STC TD16 K3
C1814	47p	10	500V	Ceramic Disc	ITT/STC CDC 8/WK
C1815	100n	20	100V	Ceramic Disc	ITT/STC 8131M-100-0104
C1816	100n	20	100V	Ceramic Disc	ITT/STC 8131M-100-0104
IC1801	SN74LS85-N				Texas
IC1802	SN74LS139-N				Texas
IC1803	SN74SL244-N				Texas
IC1804	P8253				Intel
IC1805	SN74LS04-N				Texas
IC1806	SN74LS 75-N				Texas
IC1807	CD4053BCN				National
IC1808	LF412CN				National
IC1809	LF412CN				National

(3245 - ANALOG OUTPUT OPTION - Continued) (N/A to 3240)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
D1801	LM329CZ				National
TR1801	VN2222L FET				Siliconix
PL1802	15-way Male Connector				Hunter (2E) 08P15L0.5
SK1801	64-way Indirect Male Connector				Vero 17.28760
SK1802	15-way Indirect Female Connector				Hunter (2E) 08S015W0.5

6.17 3240/3245 - CRT SUB-ASSEMBLY MkI

D1002	1N5817				Motorola
D1003	1N5817				Motorola

Cathode Ray Tube:

MkI	(No implosion protection)			C822P4	NEC
MkII	(With implosion protection)			C8M47P4-SB	NEC
CRT	Drive Module: MB12/20/18/090/5/FA/TTL				KME

6.18 RS232C INTERFACE OPTION (N/A to 3240)

R200	2k2	5	0.3W	Film	Mullard SFR25
R201	220R	5	2.5W	Wirewound (when fitted)	Welwyn W21
R202	220R	5	2.5W	Wirewound (when fitted)	Welwyn W21
R203	3k	5	0.3W	Film	Mullard SFR25
R204	47R	5	2.5W	Wirewound (when fitted)	Welwyn W21
R205	75k	5	0.3W	Film	Mullard SFR25
R206	47R	5	2.5W	Wirewound (when fitted)	Welwyn W21
R207	47R	5	2.5W	Wirewound (when fitted)	Welwyn W21
R208	2k7	5	0.3W	Film	Mullard SFR25
R209	1M	5	0.3W	Film (when fitted)	Mullard SFR25
R210	x4k7			Resistor Network	VTM 560-1
R211	x4k7			Resistor Network	VTM 560-1

(3245 - RS232C INTERFACE OPTION - Continued) (N/A to 3240)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
C200	100n		63V	Ceramic Disc	Siemens B37449
C201	10µ		25V	Electrolytic	Mullard 015-16109
C202	100n		63V	Ceramic Disc	Siemens B37449
C203	10µ		25V	Electrolytic	Mullard 015-16109
C204	100n		63V	Ceramic Disc	Siemens B37449
C205	100n		63V	Ceramic Disc	Siemens B37449
C206	100n		63V	Ceramic Disc	Siemens B37449
C207	100n		63V	Ceramic Disc	Siemens B37449
C208	100n		63V	Ceramic Disc	Siemens B37449
C209	100n		63V	Ceramic Disc	Siemens B37449
C210	100n		63V	Ceramic Disc	Siemens B37449
C211	100n		63V	Ceramic Disc	Siemens B37449
C212	100n		63V	Ceramic Disc	Siemens B37449
C213	100n		63V	Ceramic Disc	Siemens B37449
C214	100n		63V	Ceramic Disc	Siemens B37449
C215	10p	1p	160V	Polystyrene (when fitted)	Suflex HS
C216	47p	2.5	160V	Polystyrene (when fitted)	LCR FSC
C217	390p	2.5	160V	Polystyrene	LCR FSC
C218	390p	2.5	160V	Polystyrene	LCR FSC
C219	390p	2.5	160V	Polystyrene	LCR FSC
C220	390p	2.5	160V	Polystyrene	LCR FSC
C221	220n		10V	Ceramic Disc	Erie 811T10V

Ref	Type	Supplier & Type No.
TR200	BC184	Texas
TR201	BC184	Texas
TR202	2N3053	RCA
IC200	SN74LS136N	Texas
IC201	SN74LS136N	Texas
IC202	SN74LS10N	Texas
IC203	SN74LS136N	Texas
IC204	SN74LS04N	Texas
IC205	DM81LS95N	National
IC206	DM81LS95N	National
IC207	DM81LS95N	National
IC208	INS8250	National
IC209	DS1488N	National
IC210	DS1489N	National
PL201	64-way Indirect Male Connector	Vero 17-2876D
S201	Switch, DIL, 16 pin	ERG SDS 8
S202	Switch, DIL, 16 pin	ERG SDS 8
S203	Switch, DIL, 16 pin	ERG SDS 8
S204	Switch, DIL, 12 pin	ERG SCS 6
SK201	25-way Indirect Female Connector	McMurdo DB-25-S-N

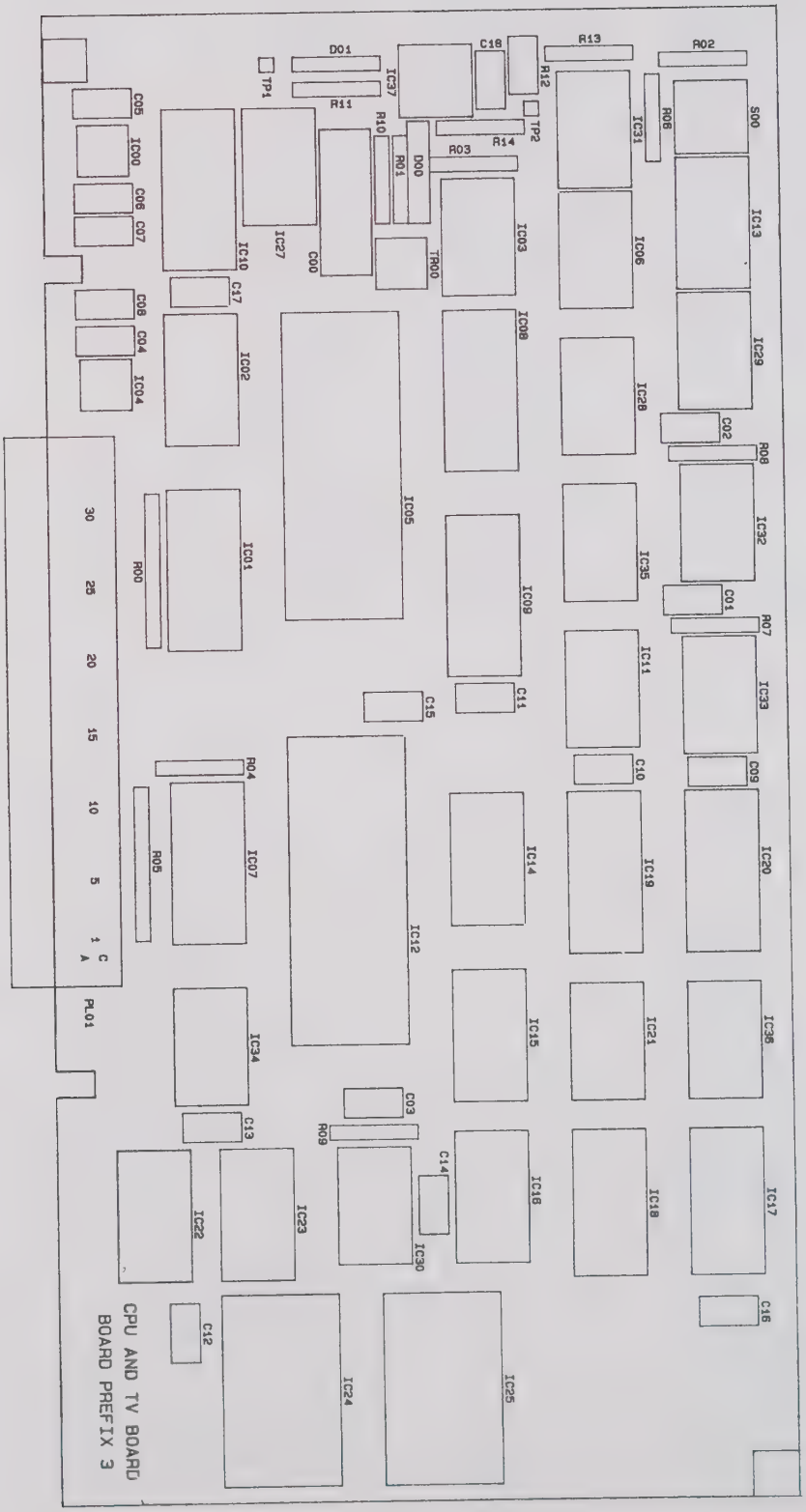


Fig. 6.1
CPU & TV
PCB Layout

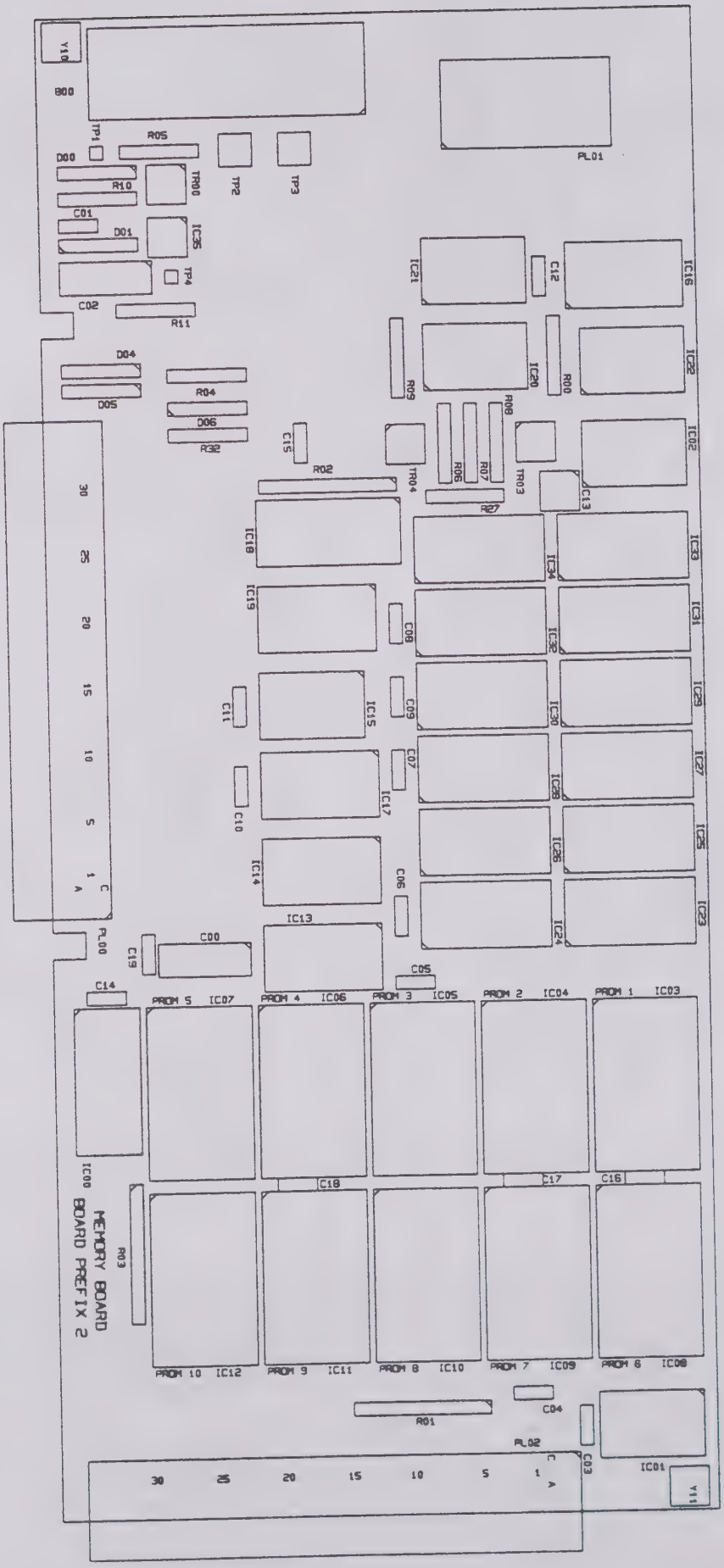


Fig. 6.3
Memory MkI
PCB Layout

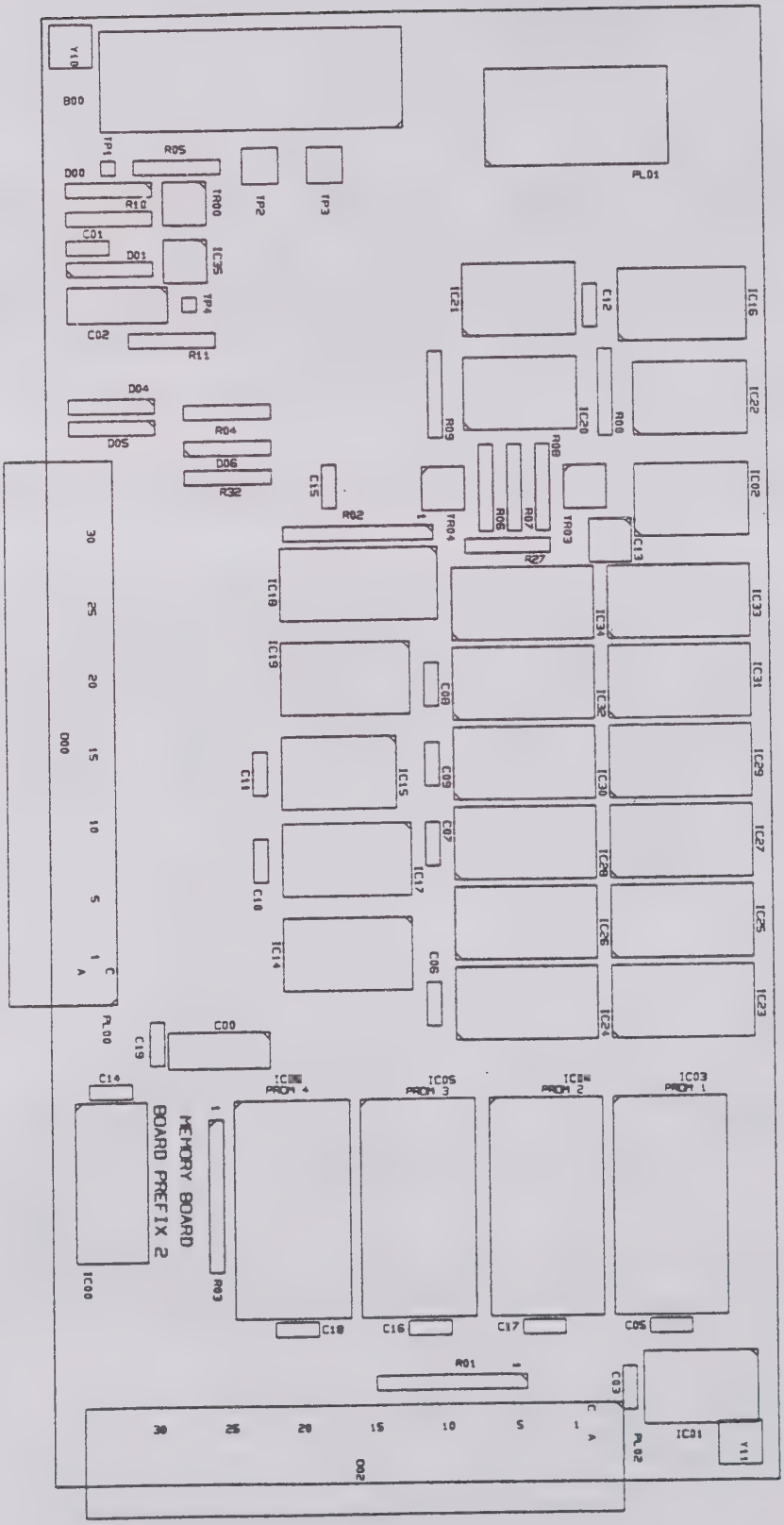


Fig. 6.5
Memory MkII
PCB Layout

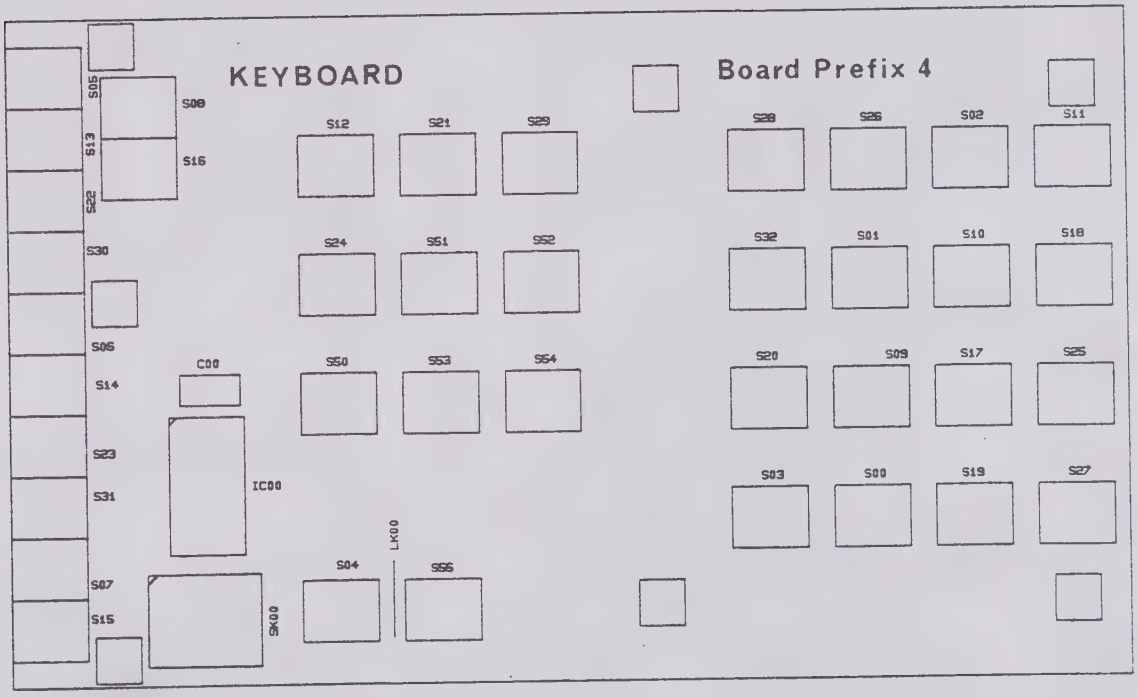


Fig. 6.7 Keyboard - PCB Layout

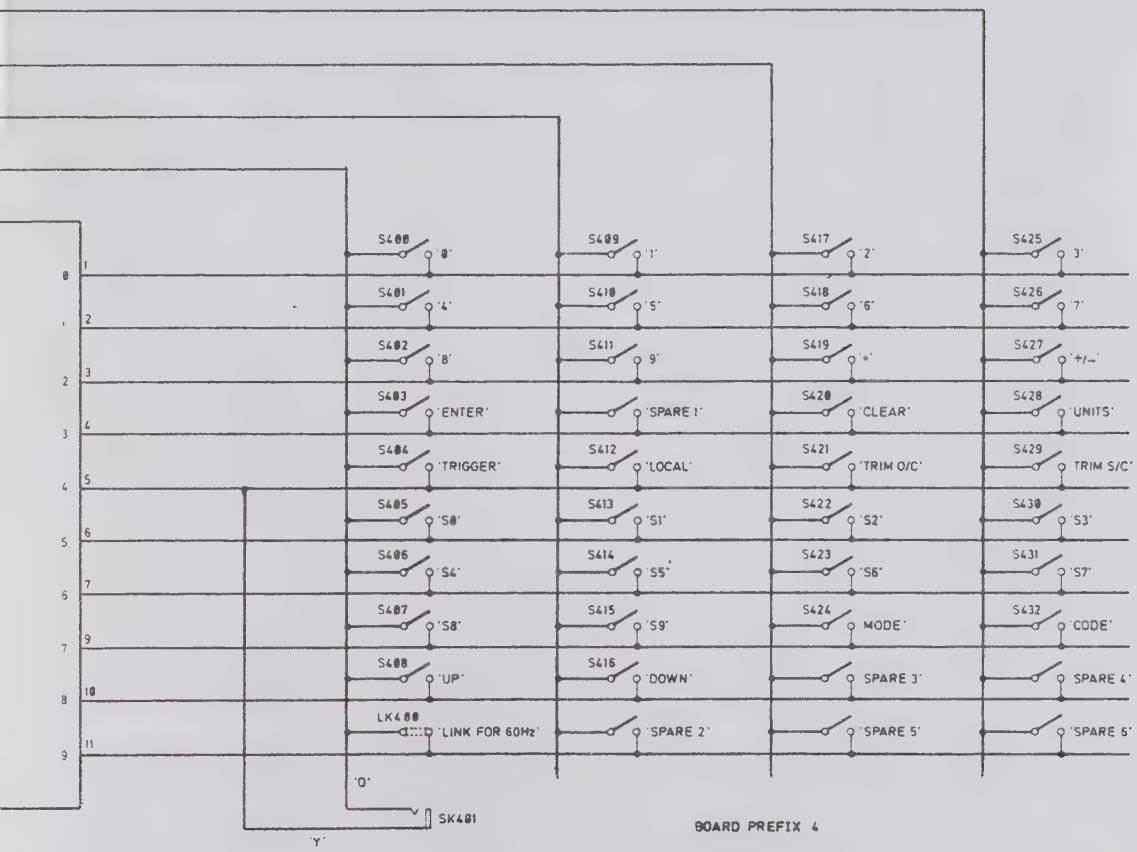
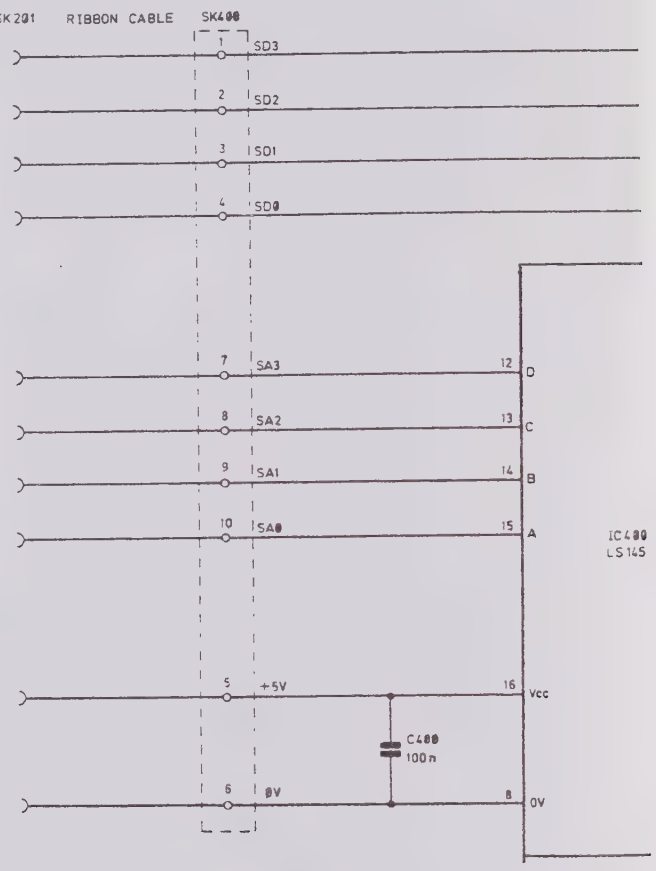


Fig. 6.8 Keyboard - Circuit Diagram (DV2/25521/P1)

NOTE: SK400 IS A TRANSITION CONNECTOR



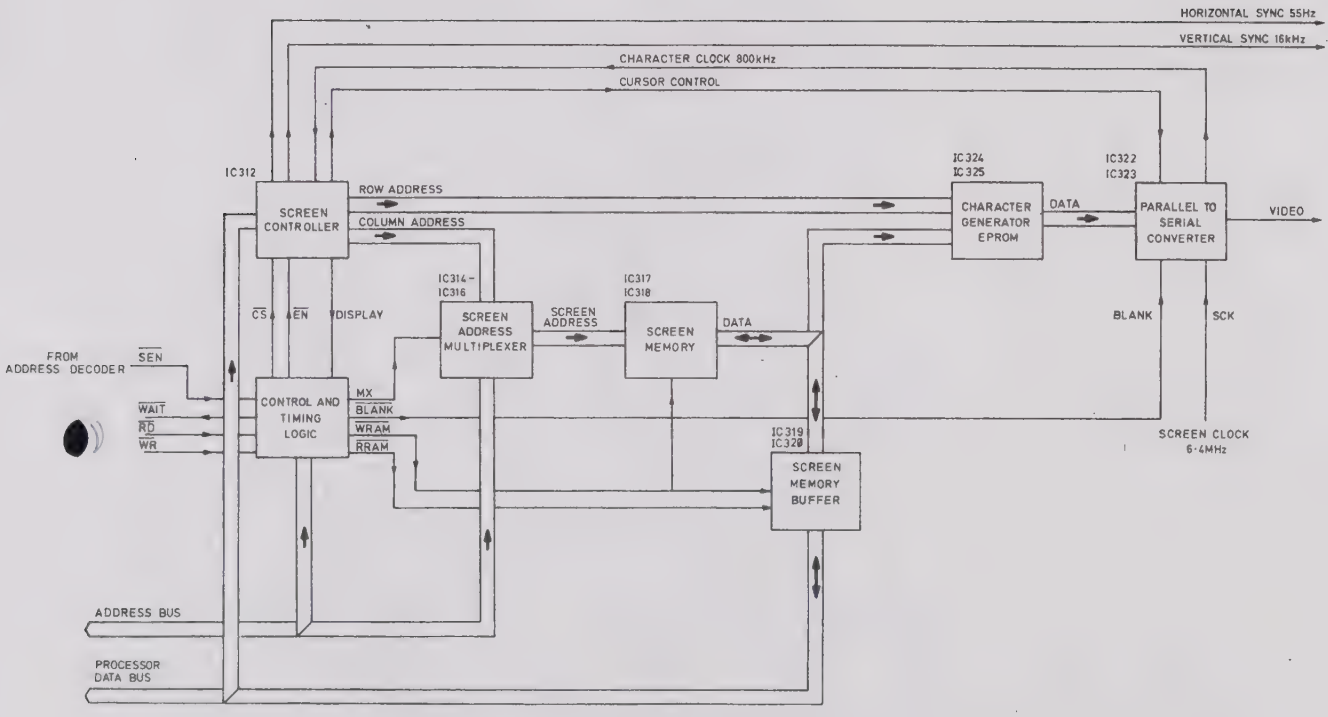


Fig. 6.9 Screen Display Generator - Block Diagram

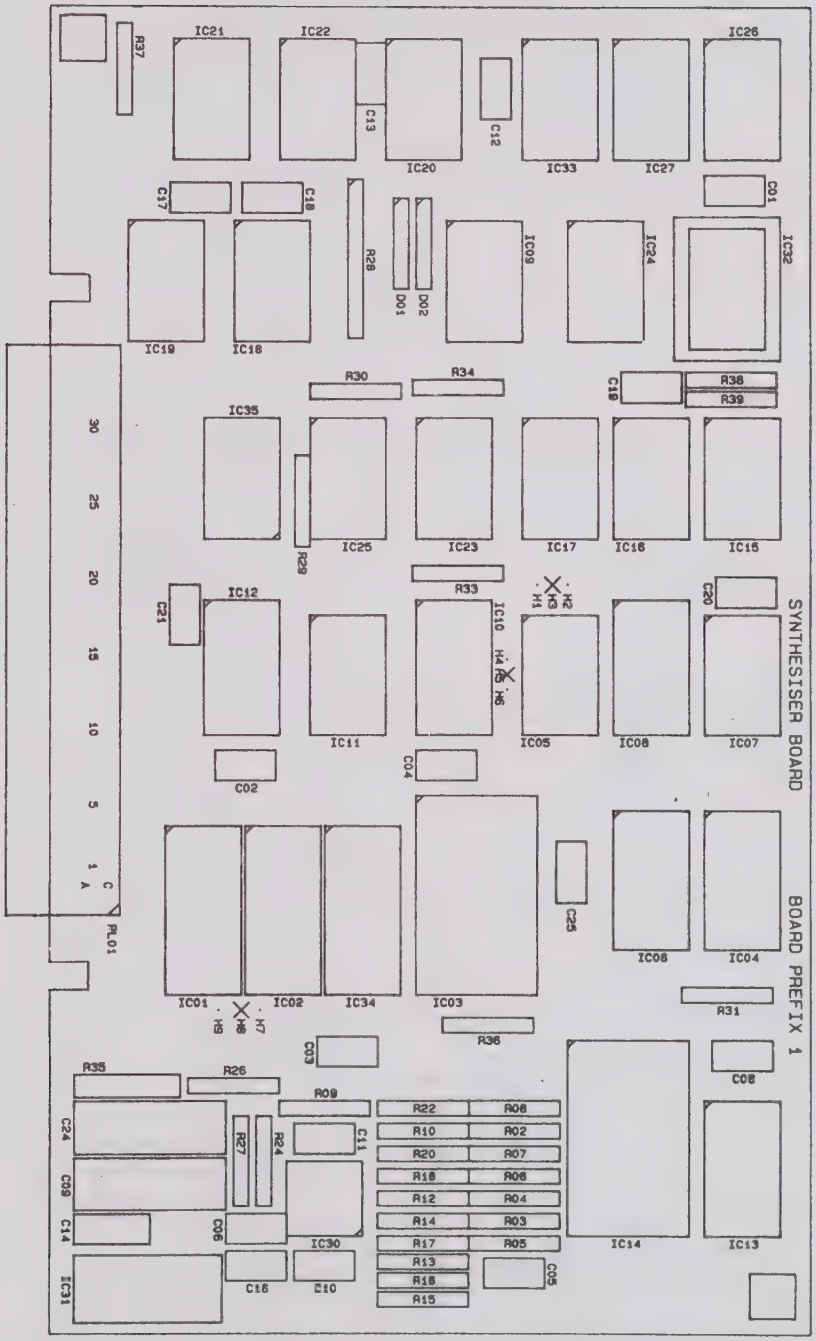


Fig. 6.10 Synthesiser MkI - PCB Layout

(Board population differs for MkI & MkII - see Components List)

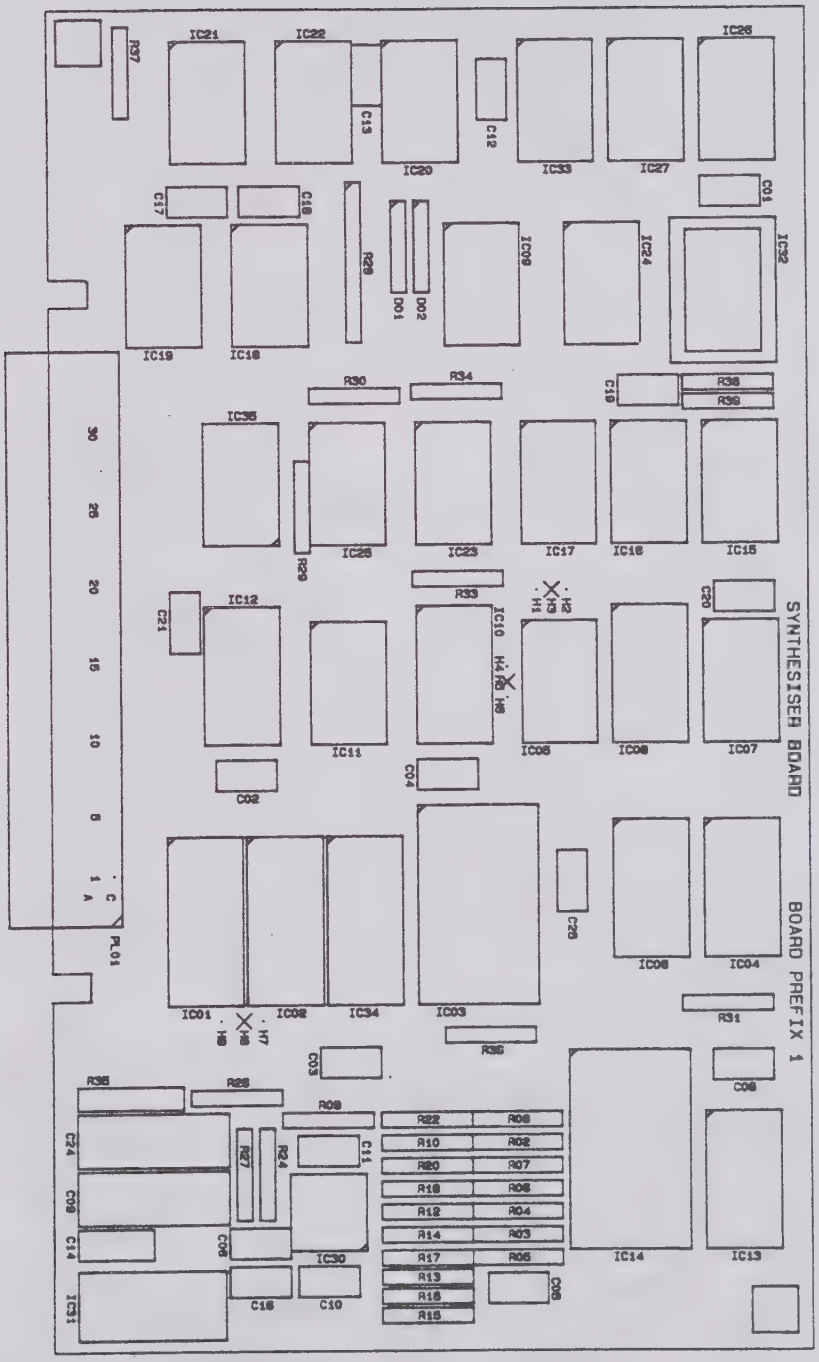


Fig. 6.12 Synthesiser MkII - PCB Layout

(Board population differs for MkI & MkII - see Components List)

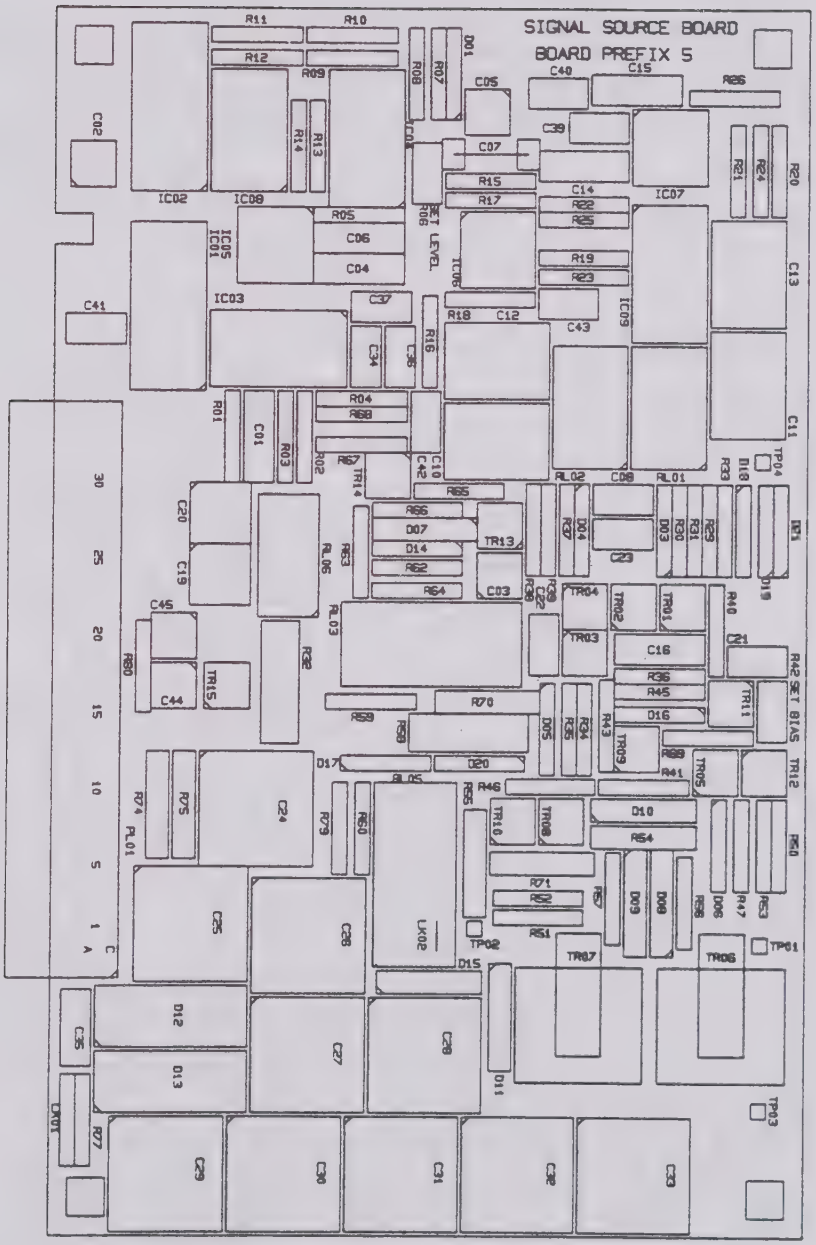


Fig. 6.14 Signal Source - PCB Layout

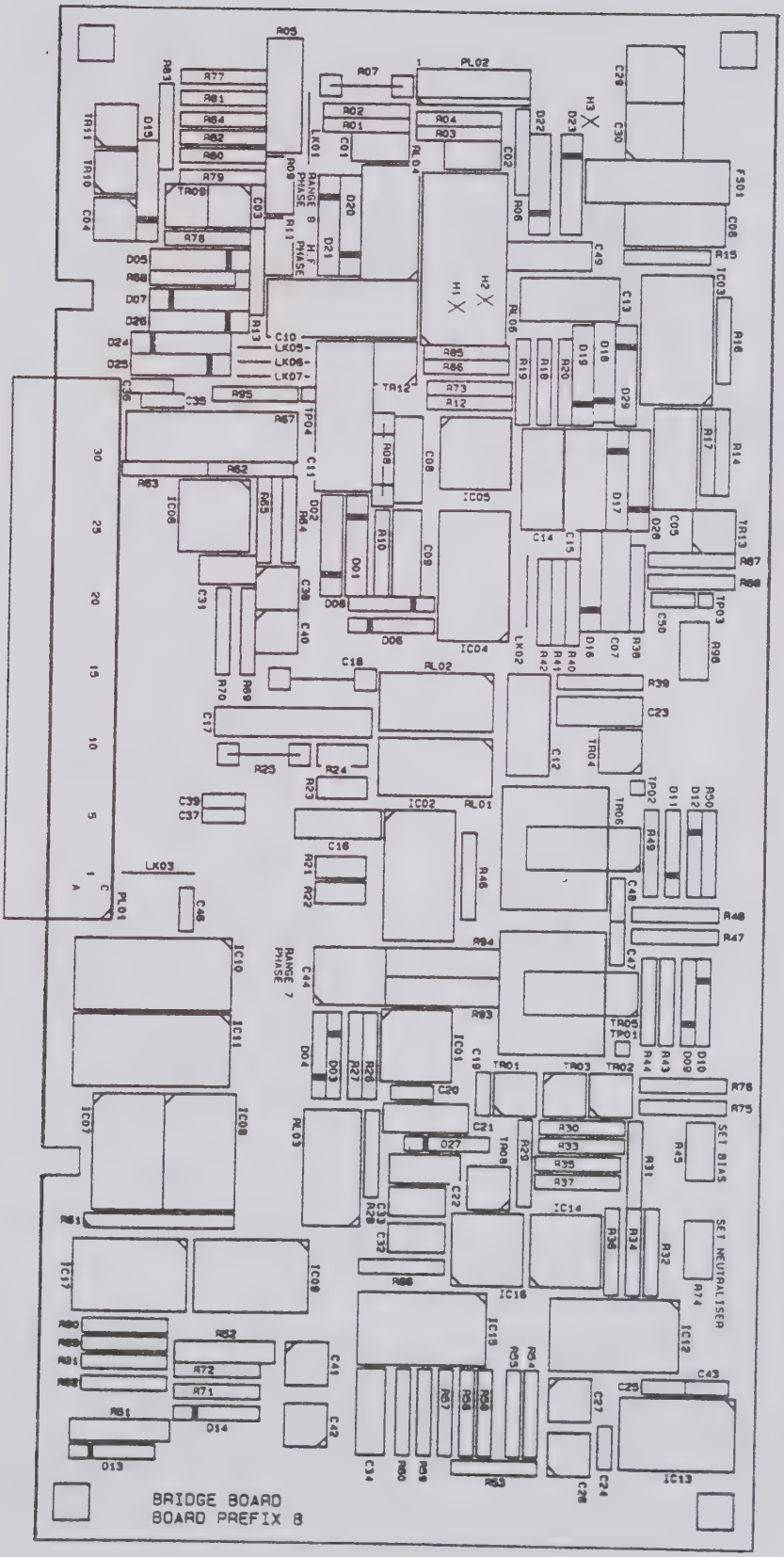


Fig. 6.16
Bridge Board
PCB Layout

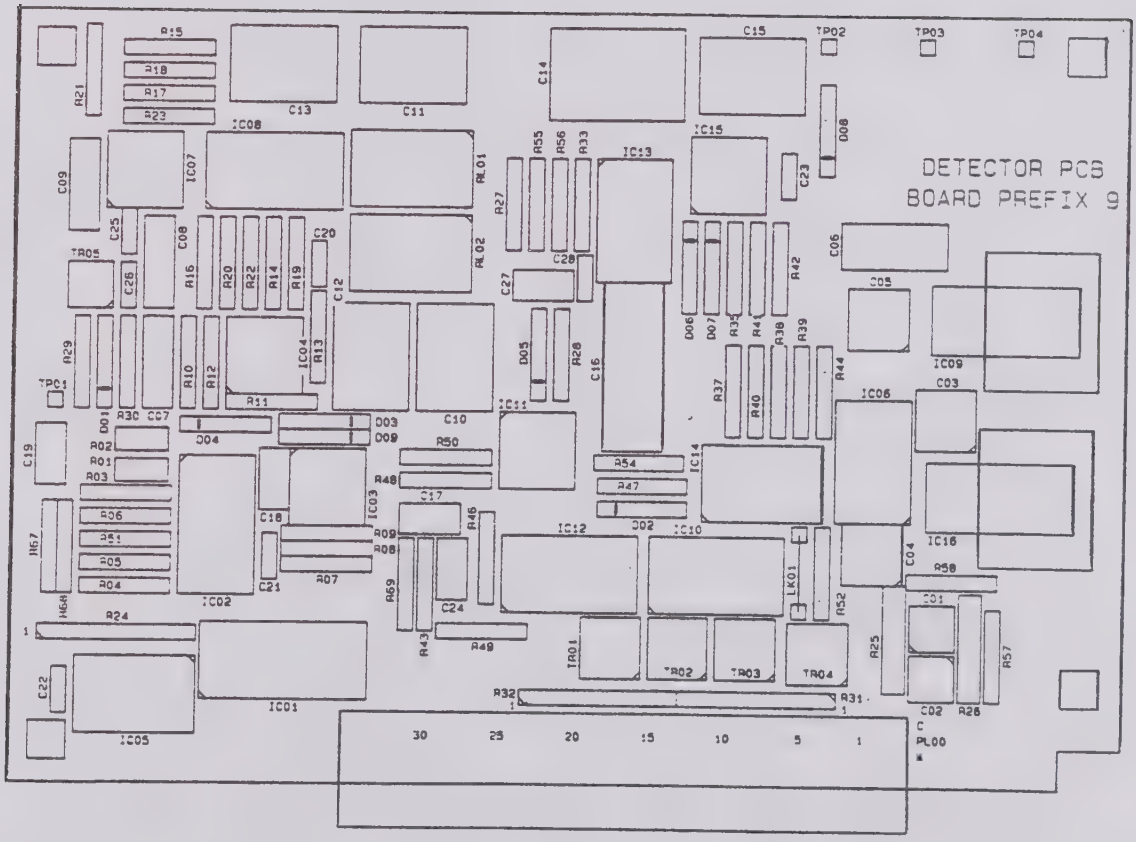


Fig. 6.18 Detector - PCB Layout

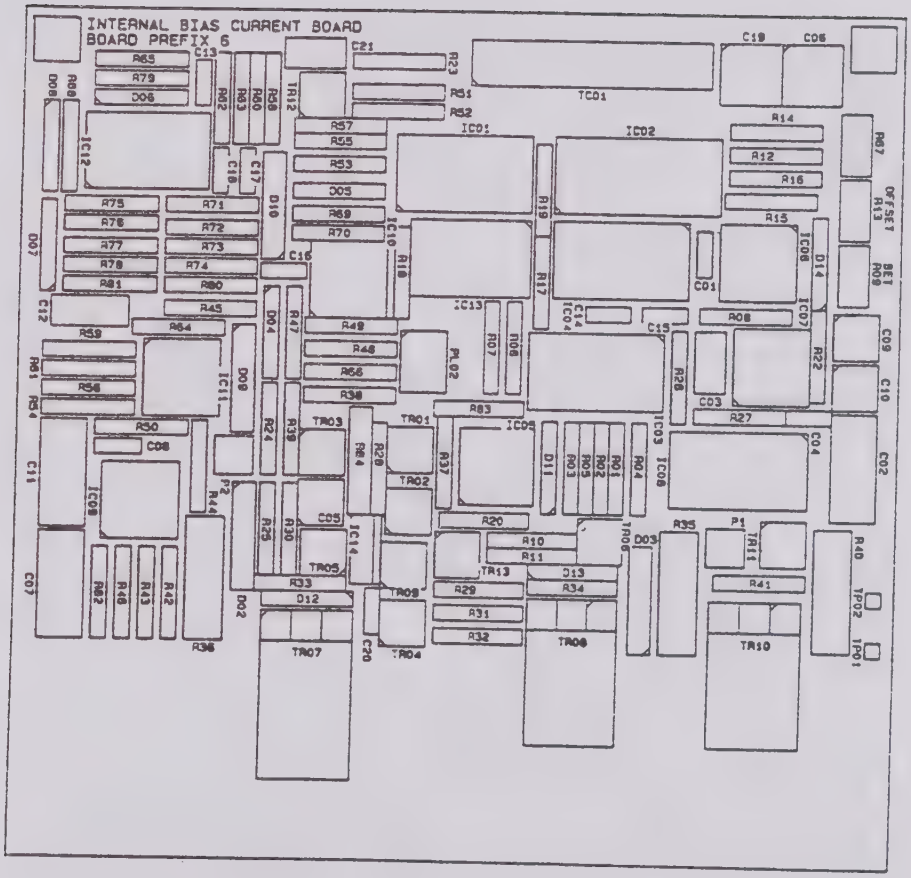


Fig. 6.20 Internal Bias Current - PCB Layout

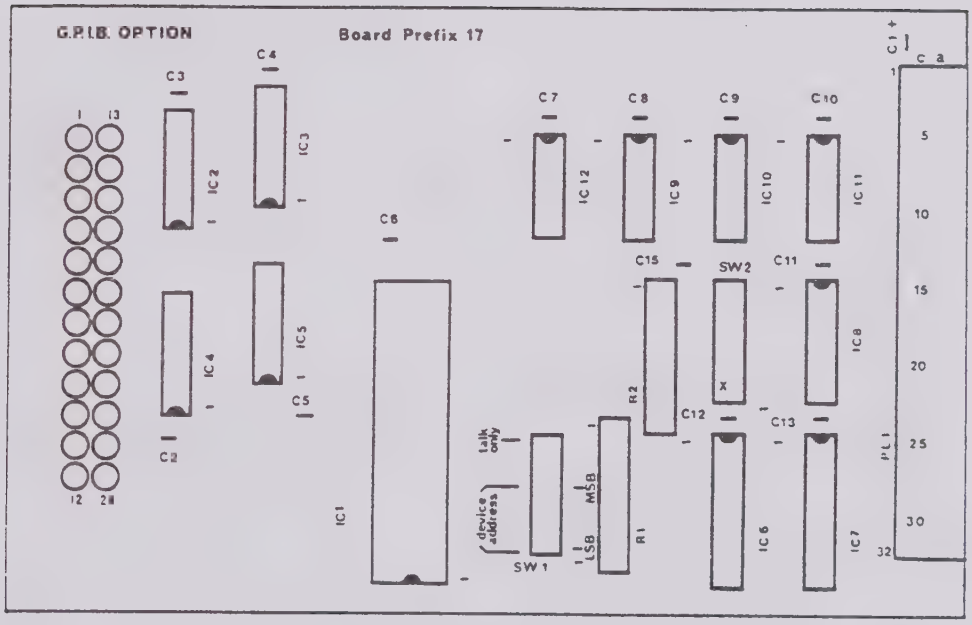


Fig. 6.22 GPIB/SHI Option - PCB Layout

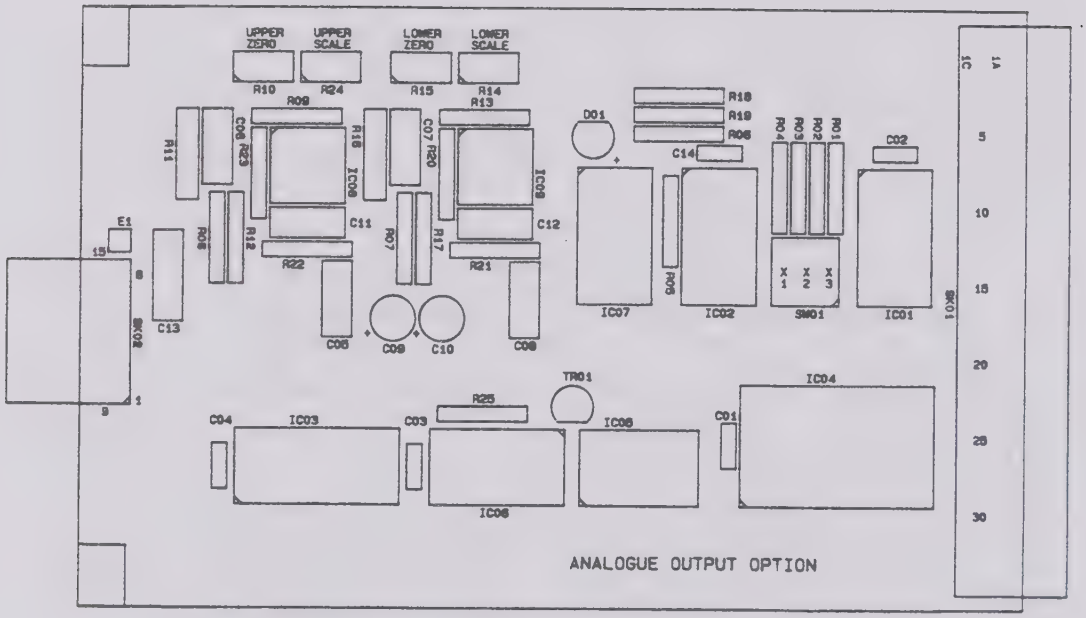


Fig. 6.24 Analog Output Option - PCB Layout

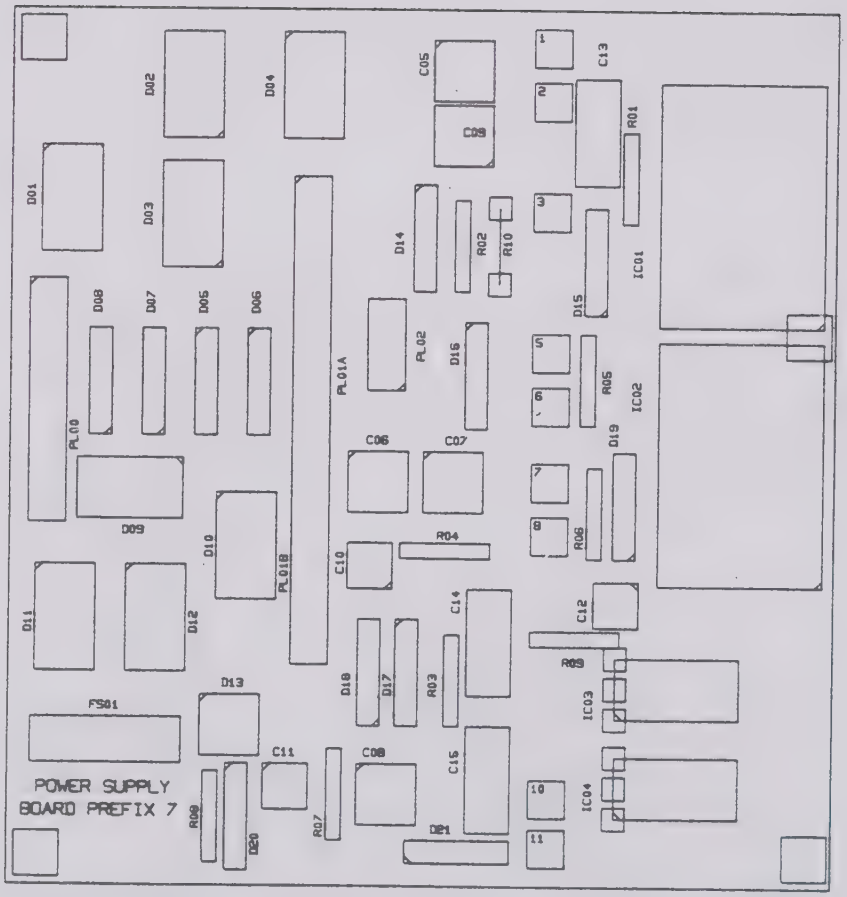


Fig. 6.26 Power Supplies - PCB Layout

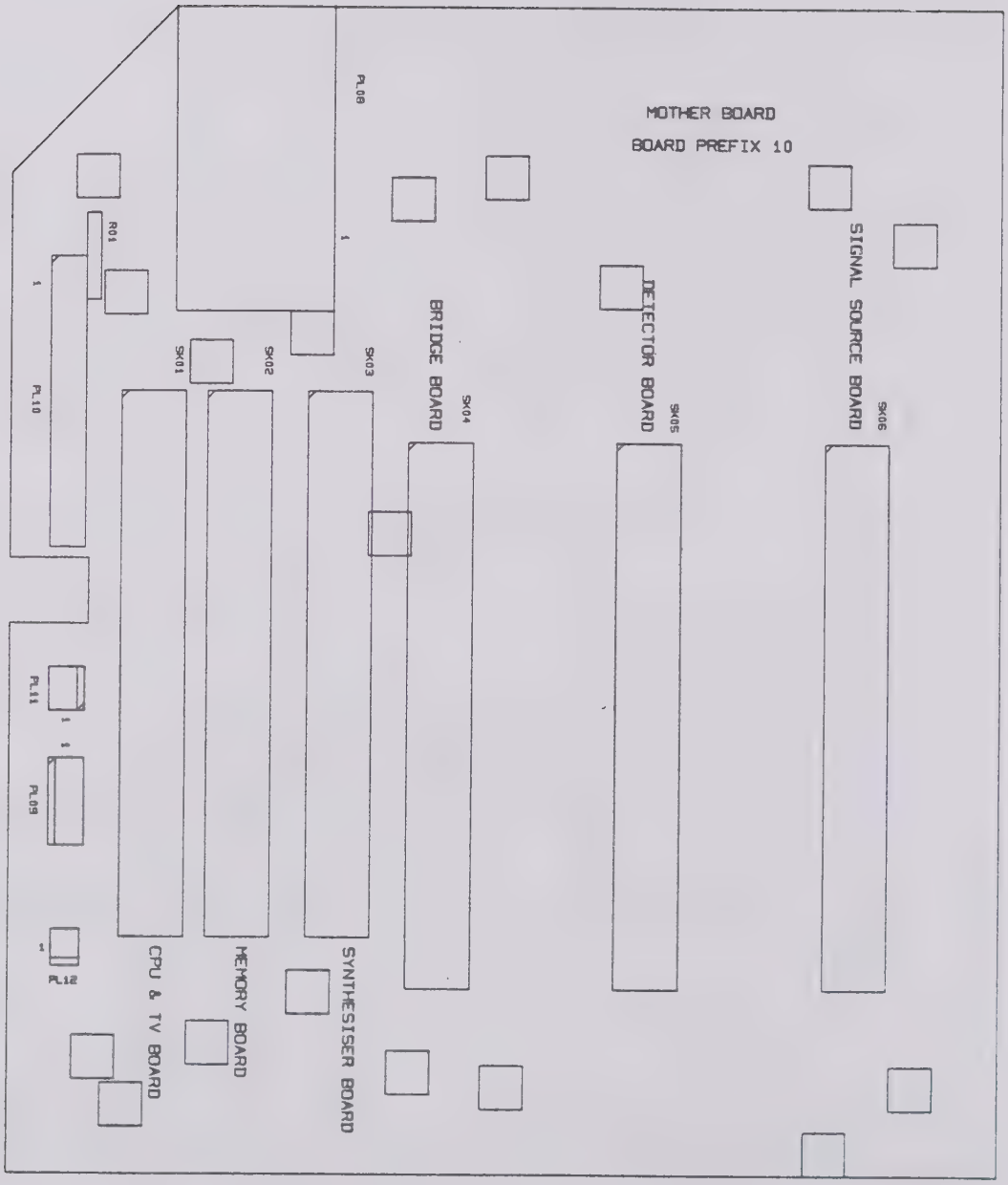
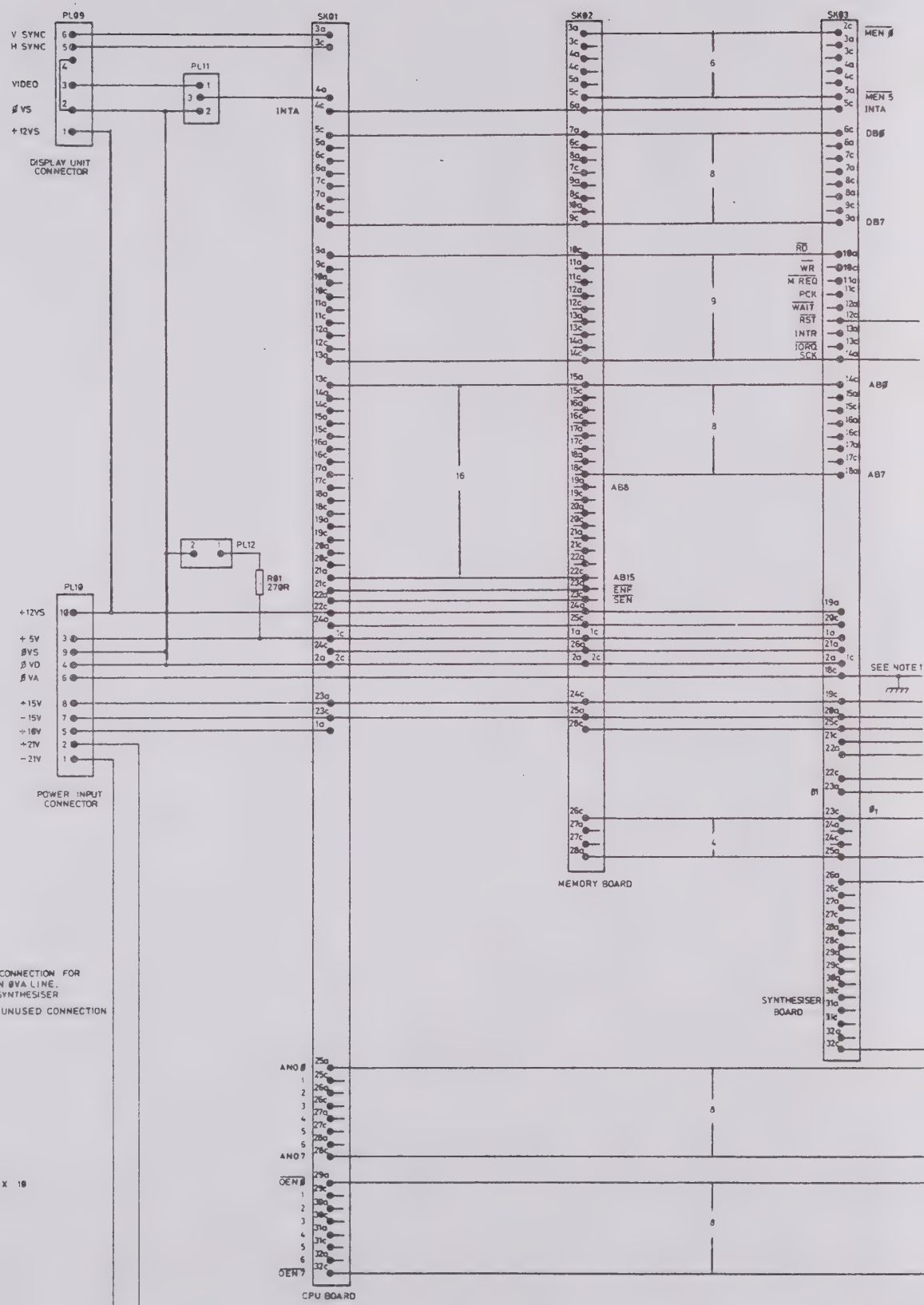


Fig. 6.28 Mother Board - PCB Layout



NOTES

1. MAIN CHASSIS CONNECTION FOR INSTRUMENT ON øVA LINE, ADJACENT TO SYNTHESISER
2. X INDICATES UNUSED CONNECTION

BOARD PREFIX 19

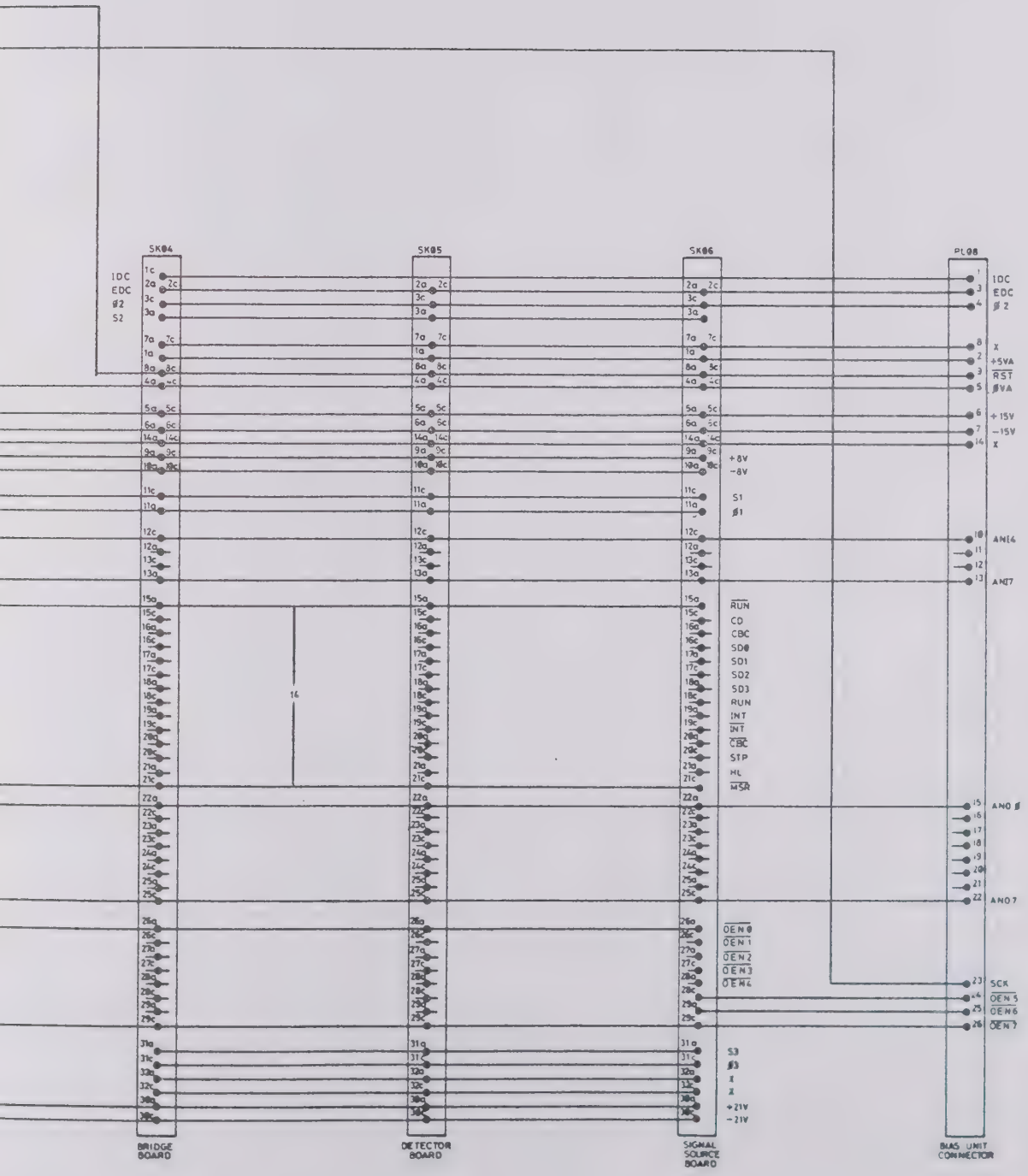
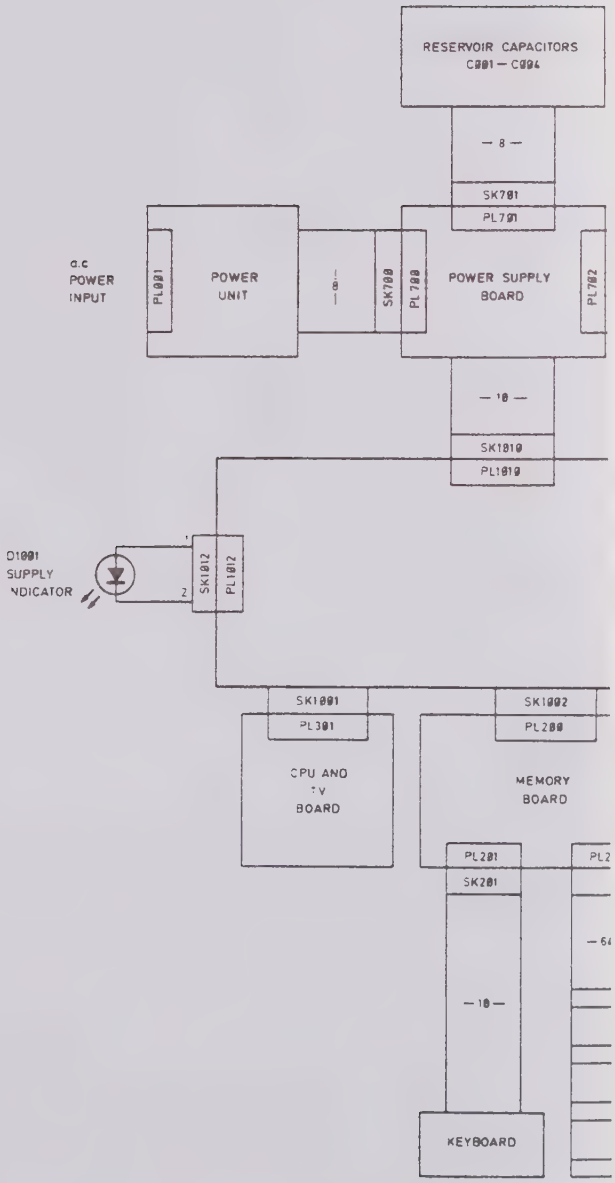


Fig. 6.29 Mother Board - Circuit Diagram (DV1/25514/P1)


RESERVOIR CAPACITORS
C001 — C004
— 8 —
SK701
PL701
a.c
POWER
INPUT
PL001
POWER
UNIT
— 8 —
SK700
PL700
POWER SUPPLY
BOARD
PL702
— 10 —
SK1010
PL1010
D1001
SUPPLY
NDICATOR
1
2
SK1012
PL1012
SK1001
PL301
SK1002
PL200
CPU AND
T.V
BOARD
MEMORY
BOARD
PL201
SK201
PL2
— 64
— 10 —
KEYBOARD

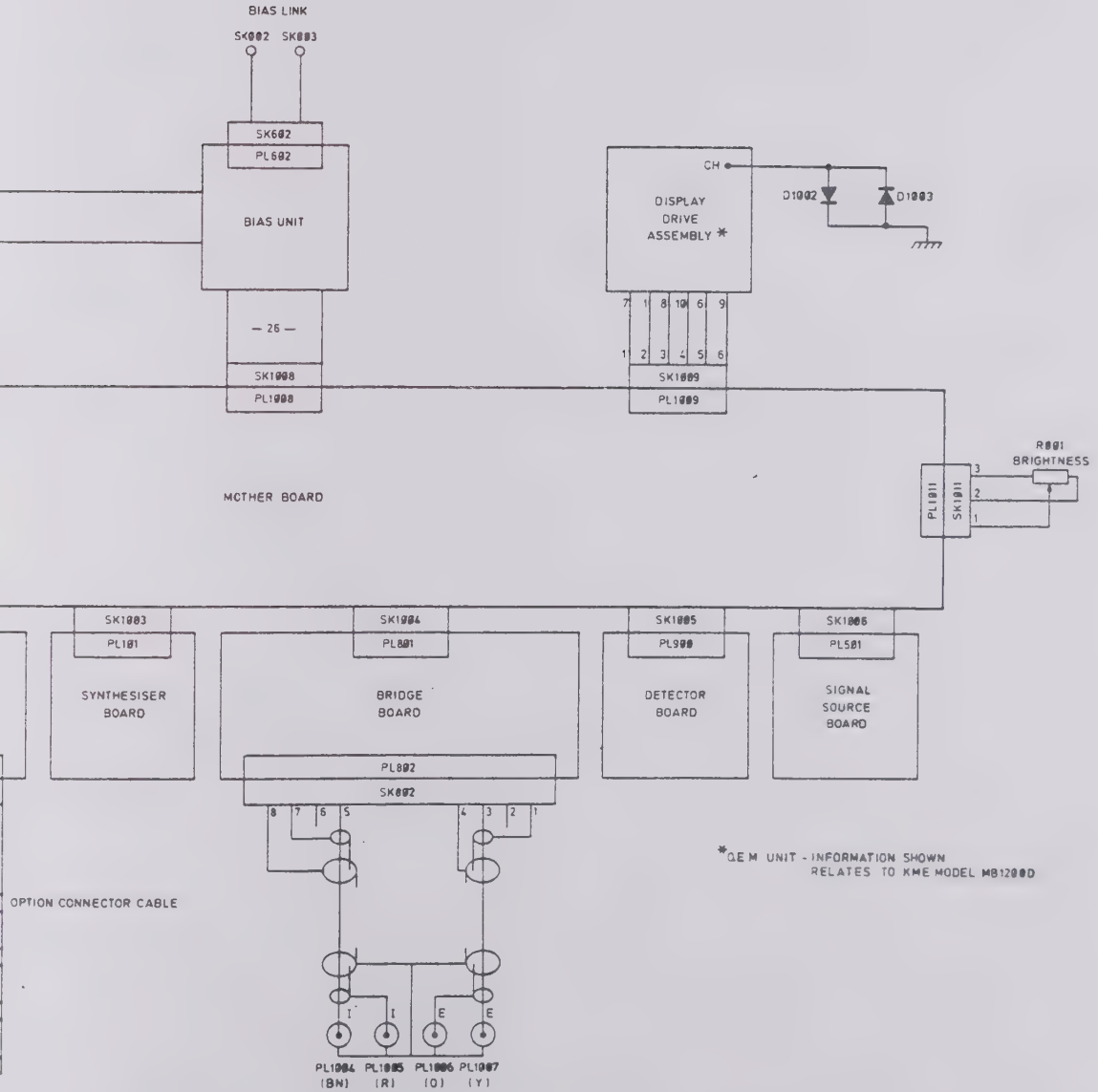


Fig. 6.30 Interconnections (DV2/25596/P2)

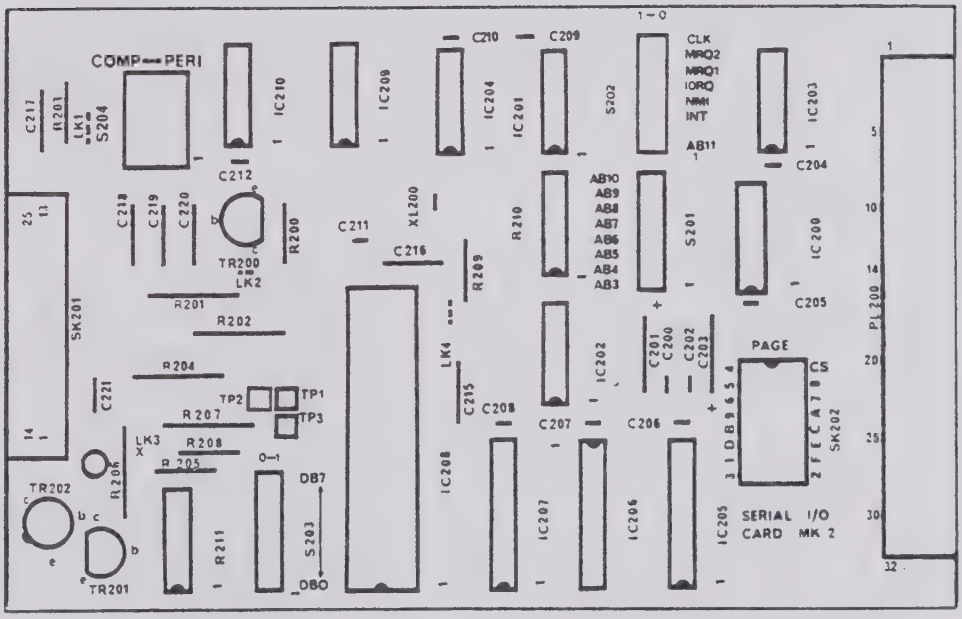
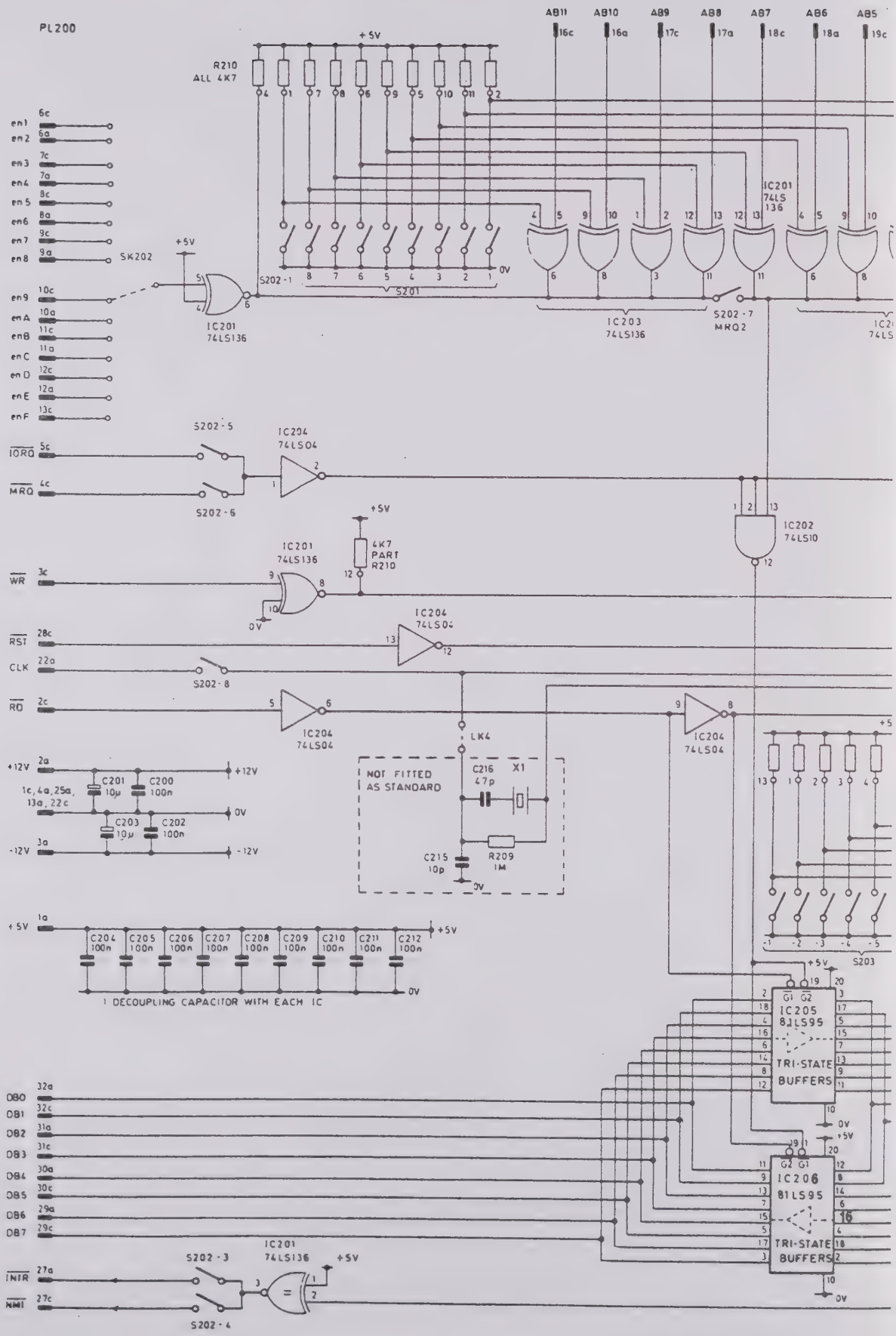
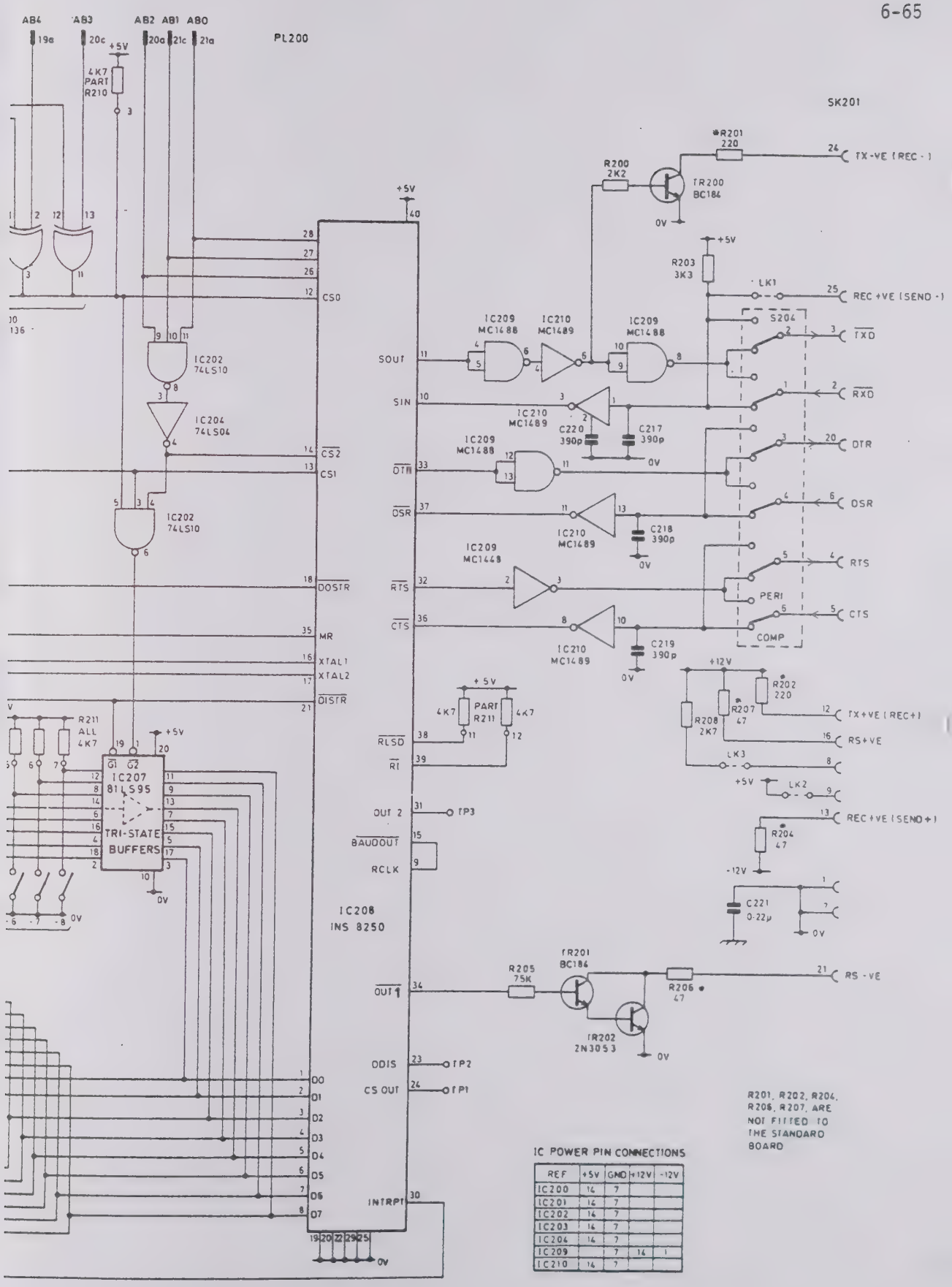


Fig. 6.32 RS232C Option - PCB Layout


PL200
+5V
R210
ALL 4K7
A811 16c
A810 16a
A89 17c
A88 17a
A87 18c
A86 18a
A85 19c
en1 6c
en2 6a
en3 7c
en4 7a
en5 8c
en6 8a
en7 9c
en8 9a
SK202
en9 10c
enA 10a
enB 11c
enC 11a
enD 12c
enE 12a
enF 13c
S202-1
S201
0V
IC201 74LS136
IC201 74LS136
IC203 74LS136
S202-7 MRQ2
S202-5
IORQ 5c
MRQ 4c
S202-6
IC204 74LS04
IC202 74LS10
4K7 PART R210
WR 3c
RST 28c
CLK 22a
S202-8
RD 2c
LK4
NOT FITTED AS STANDARD
C216 47p
X1
C215 10p
R209 1M
+12V 2a
1c, 4a, 25a, 13a, 22c
C201 10µ
C200 100n
C203 10µ
C202 100n
-12V 3a
+5V 1a
C204 100n
C205 100n
C206 100n
C207 100n
C208 100n
C209 100n
C210 100n
C211 100n
C212 100n
1 DECOUPLING CAPACITOR WITH EACH IC
S203
IC205 81LS95
IC206 81LS95
TRI-STATE BUFFERS
DB0 32a
DB1 32c
DB2 31a
DB3 31c
DB4 30a
DB5 30c
DB6 29a
DB7 29c
INTR 27a
NMI 27c
S202-3
S202-4



IC POWER PIN CONNECTIONS

REF	+5V	GND	+12V	-12V
IC200	14	7		
IC201	14	7		
IC202	14	7		
IC203	14	7		
IC204	14	7		
IC209		7	14	1
IC210	14	7		

Fig. 6.33 RS232C Option - Circuit Diagram (D02/24228/E)

6.19 3240/3245 - MEMORY BOARD MkIII PCB

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
B200				Battery Lithium	Saft Sogea LD160
C200	10µ	20%	25V	Electrolytic	Philips 030-36109
C201	100n		63V	Ceramic	Siemens B37449
C202	100n		63V	Ceramic	Siemens B37449
C203	100n		63V	Ceramic	Siemens B37449
C204	100n		63V	Ceramic	Siemens B37449
C205	100n		63V	Ceramic	Siemens B37449
C206	100n		63V	Ceramic	Siemens B37449
C207	100n		63V	Ceramic	Siemens B37449
C208	100n		63V	Ceramic	Siemens B37449
C209	100n		63V	Ceramic	Siemens B37449
C210	100n		63V	Ceramic	Siemens B37449
C211	100n		63V	Ceramic	Siemens B37449
C212	100n		63V	Ceramic	Siemens B37449
C213	100n		63V	Ceramic	Siemens B37449
C214	100n		63V	Ceramic	Siemens B37449
C215	100n		63V	Ceramic	Siemens B37449
C216	100n		63V	Ceramic	Siemens B37449
C217	100n		63V	Ceramic	Siemens B37449
C218	1n	20%	500V	Ceramic	ITT/STC CD08/WK
C219	47p	10%	500V	Ceramic	ITT/STC CD08/WK
C220	100n		63V	Ceramic	Siemens B37449
C221	10µ	20%	25V	Electrolytic	Philips 030-36109
C222	22µ		10V	Tantalum Bead	ITT/STC TAG22/10
C223	100n		63V	Ceramic	Siemens B37449
D200				Diode	Philips 1N4148
D201	3.0V			Diode Zener	Philips BZX79-C3V0
D202				Diode	Philips 1N4148
D203				Diode	Philips 1N4148
D204				Diode	Philips 1N4148
IC200				Integrated Circuit	Texas SN74LS245N
IC201				Integrated Circuit	RCA CD74HC32E
IC202				Integrated Circuit	RCA CD74HC11E
IC203				Integrated Circuit (Programmed)	NEC µPD27128D
IC204				Integrated Circuit (Programmed)	NEC µPD27128D
IC205				Integrated Circuit (Programmed)	NEC µPD27128D
IC207				Integrated Circuit (RAM)	Toshiba TC5564-APL-15
IC208				Integrated Circuit	RCA CD74HC273E
IC209				Integrated Circuit	RCA CD74HC541E
IC210				Integrated Circuit	RCA CD74HC540E
IC211				Integrated Circuit	RCA CD74HC175E
IC212				Integrated Circuit	RCA CD74HC139E
IC213				Integrated Circuit	RCA CD74HC08E
IC214				Integrated Circuit	RCA CD74HC00E
IC215				Integrated Circuit	RCA CD74HC138E
IC216				Integrated Circuit	RCA CD74HC139E
IC217	5.0V			Voltage Regulator	National LM78L05ACZ
PL200	64-way Connector		R/A		Vero 17-2876D
PL201	10-way Connector		R/A		Robinson Nugent 1DH-10PK-1SR3-TG
PL202	64-way Connector		R/A		Vero 17-2876D

(3240/3245 - MEMORY BOARD MkIII - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R200	1kO	2%		Network	Bourns 4610X-101-102
R201	1kO	2%		Network	Bourns 4610X-101-102
R202	1kO	2%		Network	Bourns 4610X-101-102
R203	47k	2%		Network	Bourns 4610X-101-473
R204	47k	2%		Network	Bourns 4610X-101-473
R205	4k7	2%		Network	Bourns 4610X-101-472
R206	1kO	2%		Network	Bourns 4610X-101-102
R207	4k7	5%	0.25W	Film	Philips SFR25
R208	4k7	5%	0.25W	Film	Philips SFR25
R209	1kO	5%	0.25W	Film	Philips SFR25
R210	1kO	5%	0.25W	Film	Philips SFR25
R211	2k7	5%	0.25W	Film	Philips SFR25
R212	10k	5%	0.25W	Film	Philips SFR25
R213	100R	5%	0.25W	Film	Philips SFR25
R214	47k	5%	0.25W	Film	Philips SFR25
R215	4k7	5%	0.25W	Film	Philips SFR25
R216	4k7	5%	0.25W	Film	Philips SFR25
R217	39R	5%	0.25W	Film	Philips SFR25
*S201	(Not fitted as standard)			Switch DIL	Erg SDS8-023
TR200				Transistor	Texas BC183
TR201				Transistor	Texas BC183
TR202				Transistor	Texas BC183

NOTE Memory Board MkI

Components List Page 6-26
Circuit Diagram " 6-33

Memory Board MkII

Components List Page 6-24
Circuit Diagram " 6-35

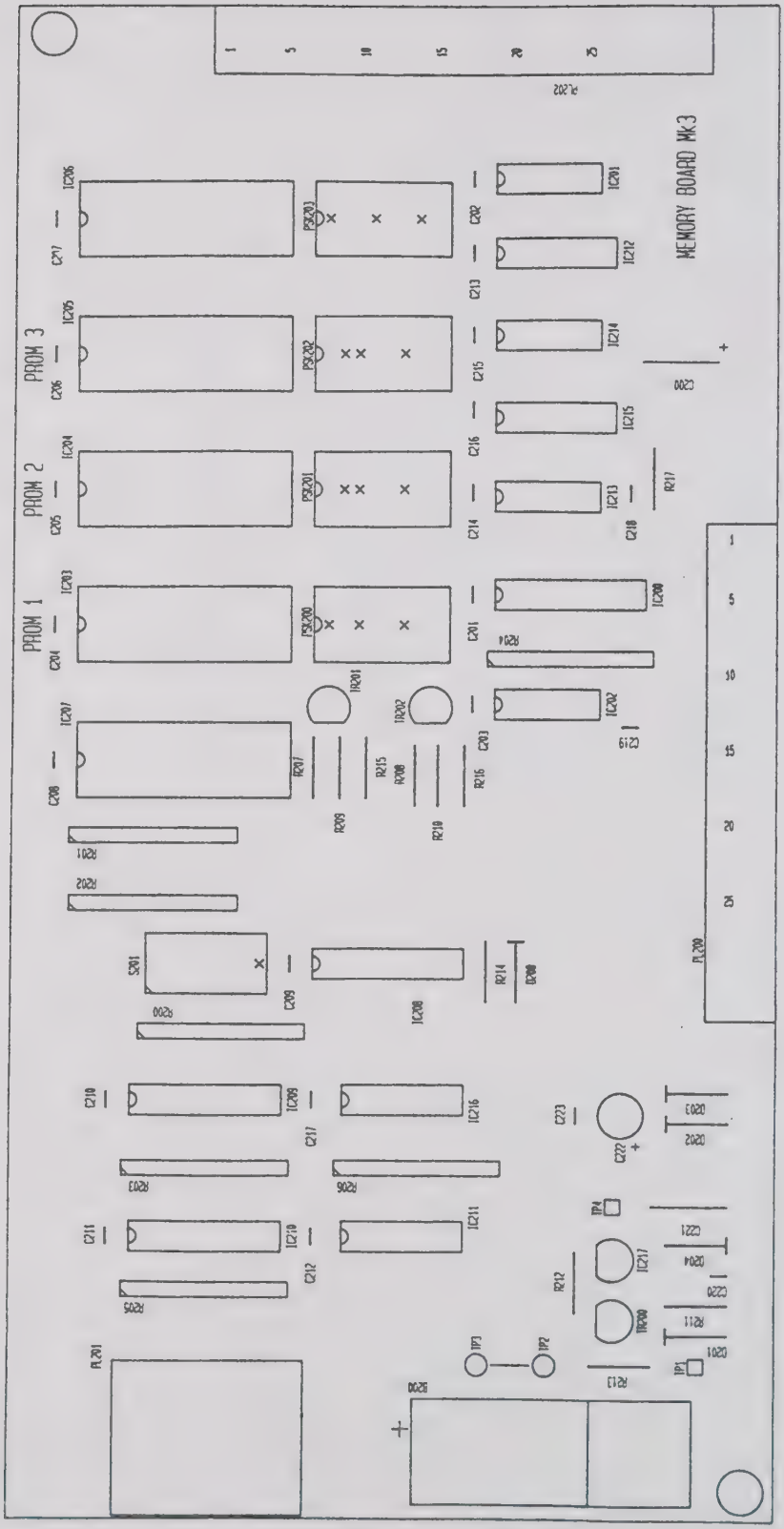
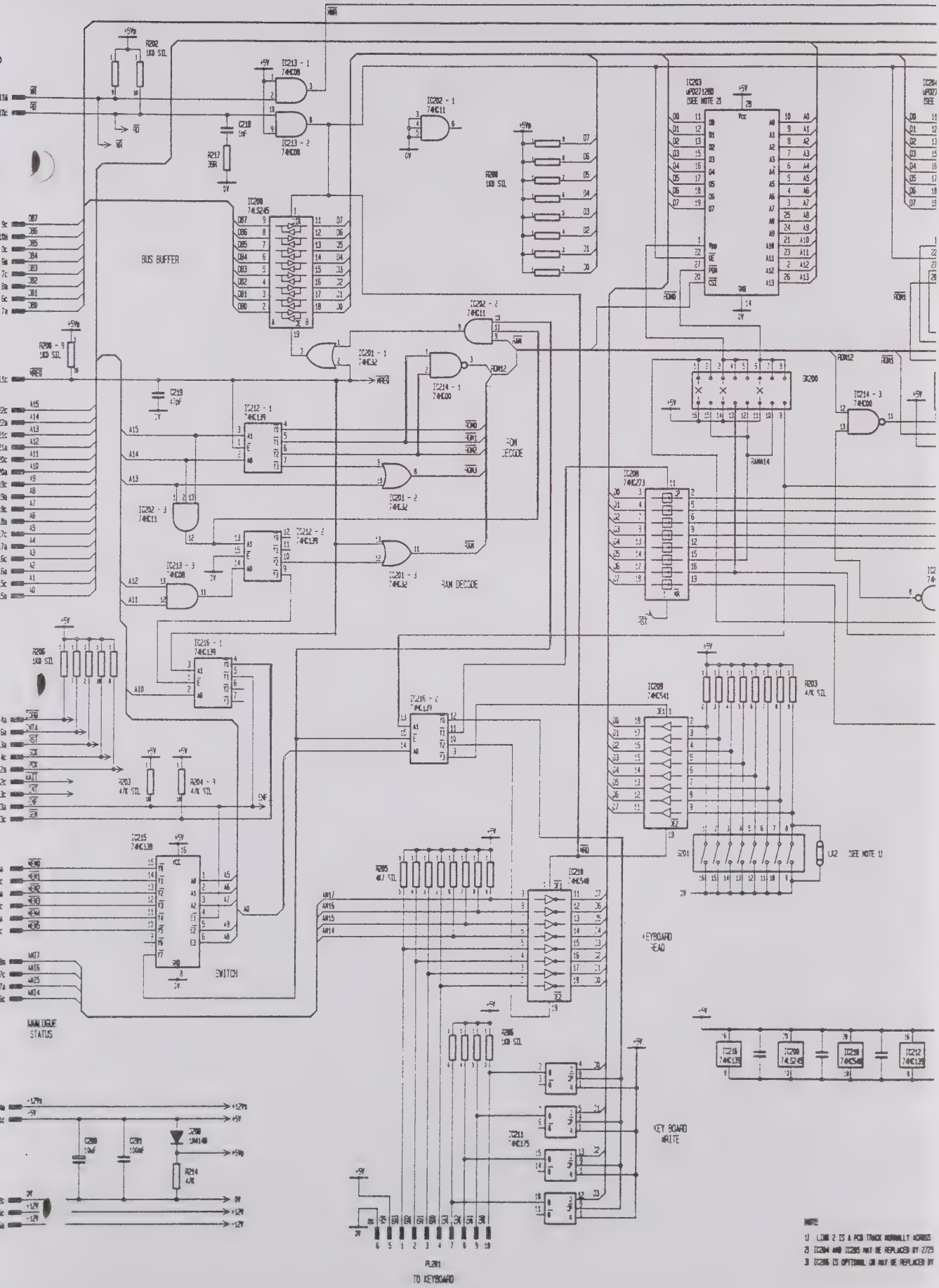


Fig. 6.34 Memory MkIII - PCB Layout


BUS BUFFER
ROM DECODE
RAM DECODE
SWITCH
RAM DECODE STATUS
KEYBOARD READ
KEY BOARD WRITE
TO KEYBOARD
SEE NOTE 1)
SEE NOTE 2)
NOTE:
1) LINK 2 IS A PCB TRACK NORMALLY ACROSS
2) IC204 AND IC205 MAY BE REPLACED BY 2725
3) IC205 IS OPTIONAL OR MAY BE REPLACED BY

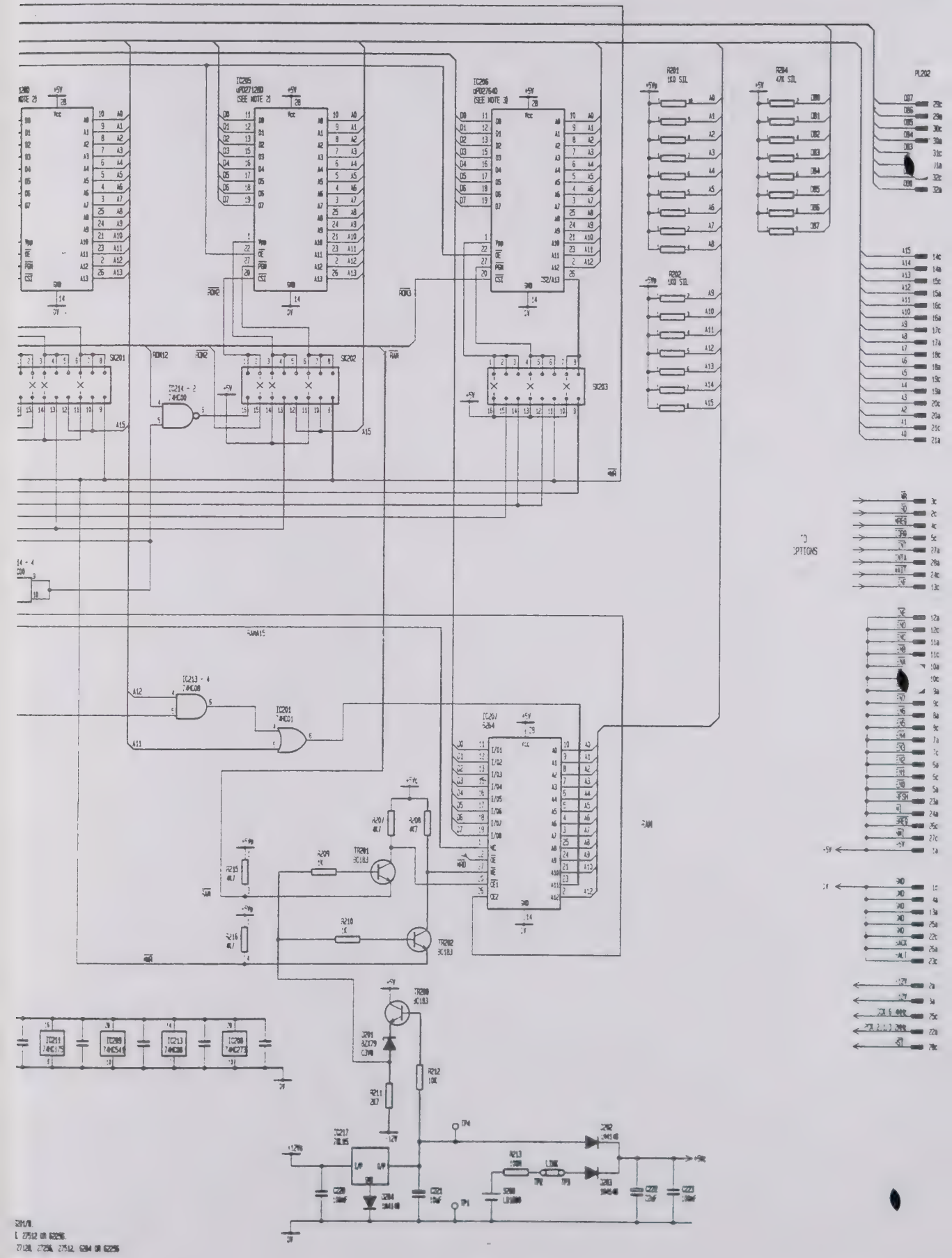


Fig. 6.35 Memory MkIII - Circuit Diagram (DV1/26666)

7 SYSTEM DESCRIPTION (3220A/1) (N/A to 3240)

7.1 GENERAL PRINCIPLES

Refer to the Simplified Block Diagram, Fig. 7.1.

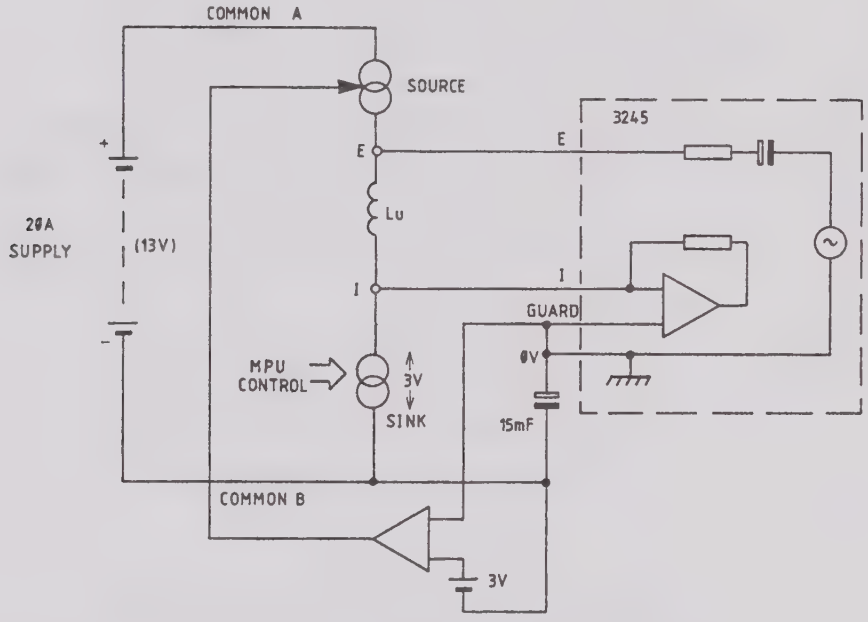


Fig. 7.1 Simplified Block Diagram

The 20A Bias Unit operates in a similar manner to the internal 1A bias circuit of the 3245. The dc bias current is fed through the inductor under test, Lu, from a floating 20A supply via two current regulators, Source and Sink, each having a high output impedance.

By grounding the bias supply to ac (the 15mF capacitor from Common B to Ground), a three-terminal measurement is achieved, the impedances of the two regulators becoming loads from each measurement terminal to Guard. Thus their shunting effect across Lu is neutralized.

Source and Sink current regulators are arranged as self-contained circuits with their own control circuits for maximum isolation and screening. Separate regulated supplies for them are provided by the Auxiliary board. This houses all the ancillary circuits required in the 3220A/1 including isolation and level shifting of all logic lines from the 3245, I terminal protection and monitor circuits.

From 1 to 5 3220A/1 units are controlled from the 3245, with input/output processing provided by an Interface Card fitted as an option in the 3245. A 25-way external ribbon cable from the Interface connects to the 3220A/1 and provides additional link-ups to any additional 3220A/1's.

7.2 DC OPERATION

Refer to the Functional Block Diagram, Fig. 7.2.

To maintain linear operation of the 20A circuit, the dc voltage across the Sink current regulator is held at 3V by a dc control loop which adjusts the Source current regulator output until the two regulator current levels are equal. The remaining supply voltage is dropped across the inductor under test, Lu, and the Source current regulator.
Because the 20A circuit is isolated from chassis, no dc current flows into the Inductance Analyzer. However, the Analyzer virtual ground circuit effectively references the I terminal and, hence, the 20A circuit, to chassis potential with the 20A negative line (COM(B)) held at 3V dc below chassis potential.

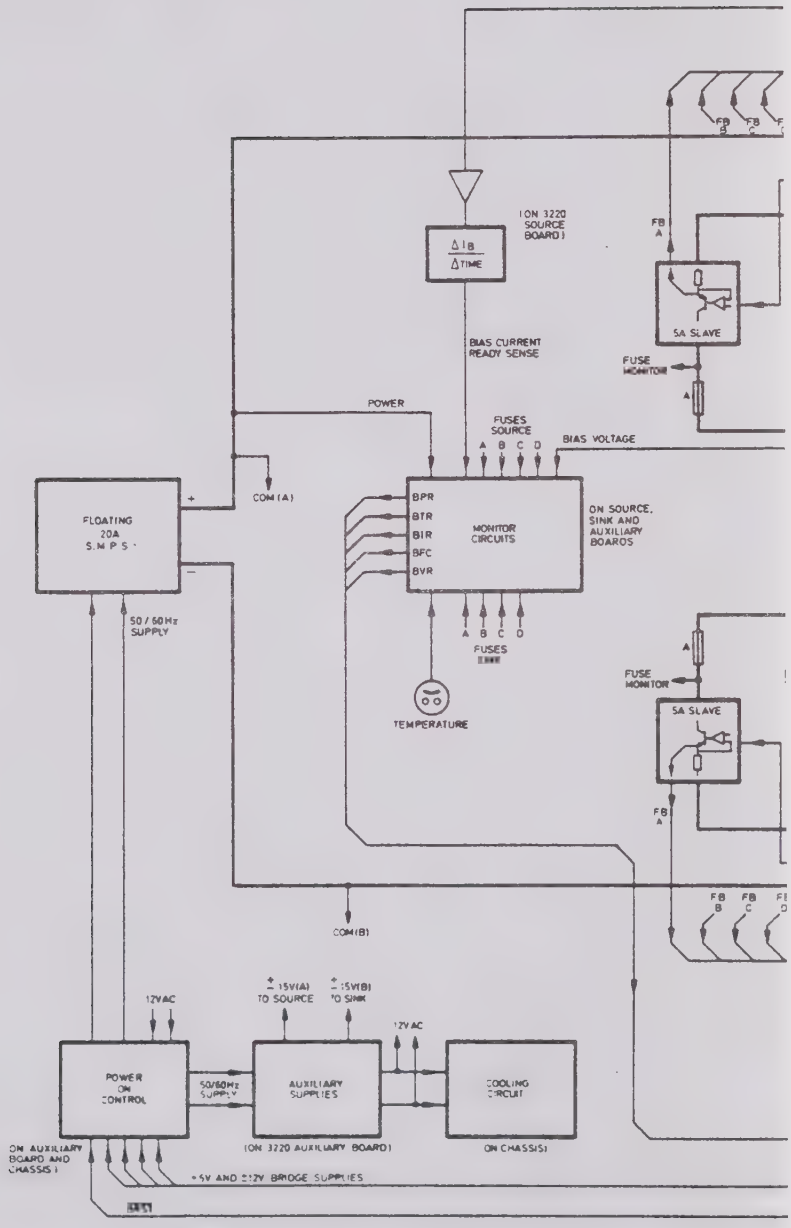
The required bias current is set via MPU control by adjustment of the Sink reference level. When no bias is required, both current regulators are inhibited, ensuring no current flows in Lu.
The correct voltage conditions are then maintained by a precharge circuit which regulates the 3V dc across the 15mF capacitor and prevents a large charging current through Lu at switch-on.

7.3 INTERFACE CARD (Board prefix 2) (N/A to 3240)

This unit is located in the 3245. Component layout is shown in Fig. 11.1 and the circuit diagram in Fig. 11.2.

7.3.1 Address Decoding

The 3220A/1 is controlled from the 3245 MPU and is arranged as a memory-mapped address location, FE 00 and FE 01 corresponding to the control and data bytes (WRITE) or the status byte (READ at FE 00 only).
IC1204 and IC1205 provide the address decoding from the system bus, Page decoding ($\overline{ENF}$) having been provided from the 3245.


FB B
FB C
ΔIB / ΔTIME
(ON 3220 SOURCE BOARD)
FB A
5A SLAVE
FUSE MONITOR
BIAS CURRENT READY SENSE
POWER
FUSES SOURCE
A B C D
BIAS VOLTAGE
FLOATING 20A S.M.P.S.
+
COM (A)
BPR
BTR
BIR
BFC
BVR
MONITOR CIRCUITS
ON SOURCE, SINK AND AUXILIARY BOARDS
50 / 60Hz SUPPLY
A B C D
FUSES
TEMPERATURE
FUSE MONITOR
5A SLAVE
FB A
FB B
FB C
COM (B)
12VAC
± 15V(A) TO SOURCE
± 15V(B) TO SINK
12VAC
POWER ON CONTROL
50/60Hz SUPPLY
AUXILIARY SUPPLIES
COOLING CIRCUIT
(ON 3220 AUXILIARY BOARD)
ON CHASSIS)
ON AUXILIARY BOARD AND CHASSIS)
+5V AND ±12V BRIDGE SUPPLIES

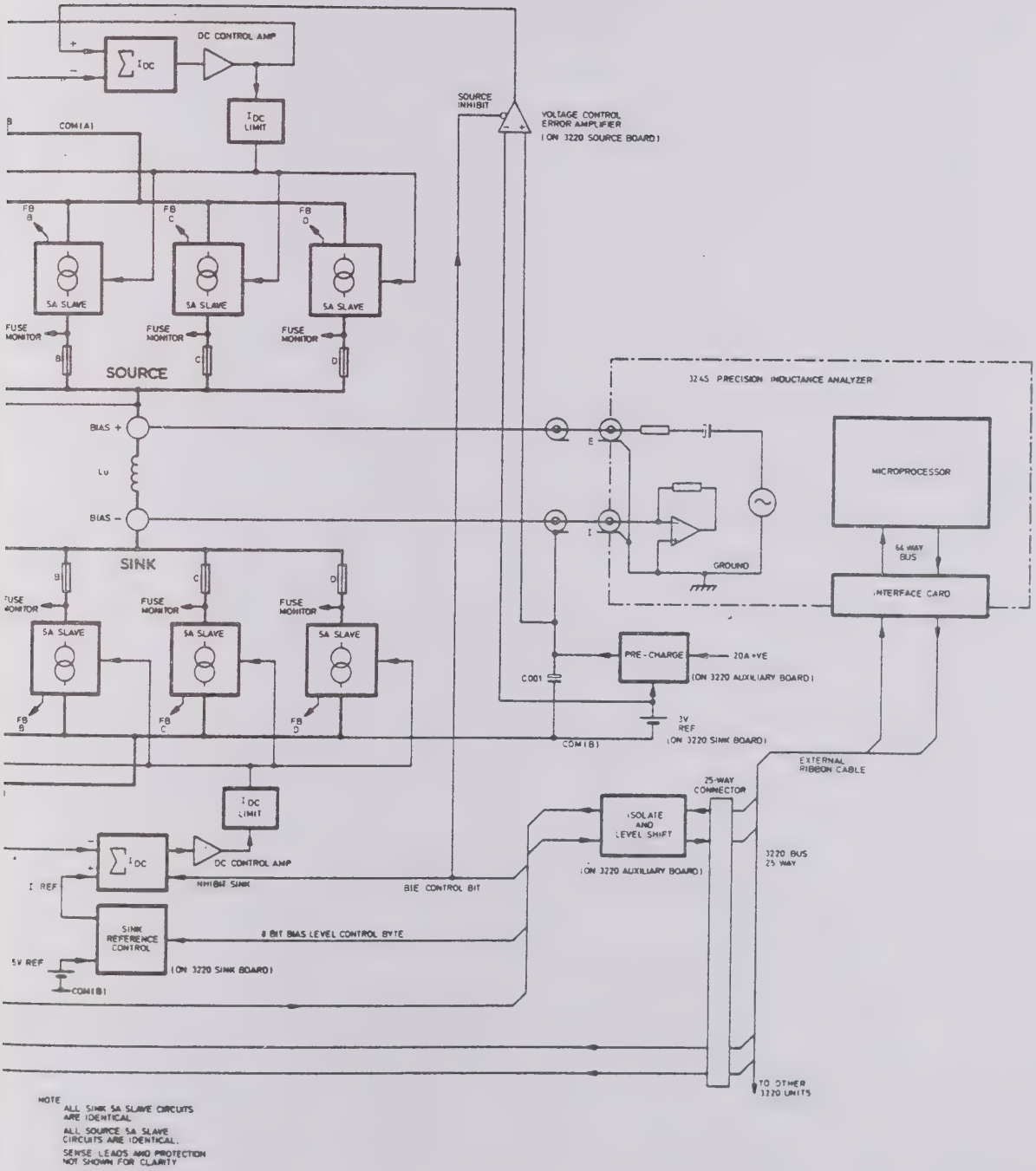


Fig. 7.2 Functional Block Diagram (DV1/25703/P1)

7.3.2 External Units Monitor

IC 207, TR201 form a delay circuit which monitors the number of 20A units connected for parallel operation.

Each 20A unit has a resistor connected to the respective Bias Monitor line (BM3220 or BM3220A - the latter also applicable to 3220A/1).

At power-up, the delay circuit is triggered by the MPU via the Bias Monitor Enable (BME) line. Capacitor C205 charges to the comparator threshold via resistance R207/R212, the associated circuit generating a reference pulse whose duration is proportional to the resistance. The MPU stores this reference time and re-sets the delay by causing C205 to discharge through TR201.

The capacitor is then switched to obtain two further times for the MPU to store: one with any 3220's connected and one with any 3220A's or 3220A/1's. These times are compared with the reference pulse and, from a look-up table, the MPU establishes the number and type of 20A units connected, and scales the bias current messages accordingly.

The latched data and control signals are fed to all the 3220A/1 units, via the external 25-way bus, to be level shifted and isolated within each 3220A/1 unit.

The 3245 system power-up reset $\overline{RST}$ is buffered ($\overline{BRST}$) and fed to all 3220A/1 units to provide a delayed 'Power On' control signal, allowing the 3245 to be operational before the Bias Units are energized. This ensures a well defined power-up/power-down condition.

7.4 AUXILIARY PCB (Board prefix 15)

Component layout: Fig. 11.3. Circuit diagram: Fig. 11.4.

7.4.1 ±15V Supplies

The 3220A/1 has two ±15V split supplies with their Commons separately referenced. The ±15V A supply is referenced to the 20A positive supply line (Common A) and feeds mainly the Source current regulator circuit. The ±15V B supply is referenced to the 20A negative supply line (Common B) and feeds the

Sink current regulator and auxiliary circuits. Each 15V supply is regulated by adjustable-type linear three-terminal series regulators (IC1505 - IC1508) with ac coupling for maximum line rejection.

7.4.2 Level Shifting

All logic signals to and from the 3245 and 3220A/1 are level-shifted and isolated to maintain the floating circuit condition within each 3220A/1.

Incoming logic lines are level-shifted and isolated from the Interface Card 5V logic, referenced to ground, to 15V logic referenced to the 3220A/1 negative line Common (B) (-3V to ground) using quad comparators (IC1501 - 1503) supplied from the bias unit auxiliary +15V (B) rail.
Status signals fed back to the 3245 are opto-isolated at IC1504.

7.4.3 Trip

IC1513, IC1512d, IC1512c and IC1511a form a trip circuit which is used to protect the 3245 virtual ground circuit if the test inductor Lu is removed while a large current is flowing. This would cause the Sink current regulator to draw current out of the 3245 I terminal circuit and discharge the 15mF ground capacitor C001 (shown on Interconnections circuit diagram).

If this happens, the voltage across the Sink regulator falls (due to diode and lead drops) which is monitored by IC1503b. The output becomes logic high and sets the latch IC1511a. The Q output inhibits the (Bias Current Enable) $\overline{\text{BIE}}$ which turns off the current regulators. The Q output is also level shifted by TR1503 to provide a status bit (Status Trip Ready) STR to the MPU. IC1513, R1540, R1535 provides a reference for the trip comparator which follows the voltage at the ground capacitor C001. R1541, C1517 provides a delay at power-up to avoid spurious firing of the trip.

The trip is reset at power up by IC1512d and subsequently whenever current is turned on (BIE goes high) via differentiator C1515, R1537.

7.4.4 Pre-Charge

IC1509a, IC1509b, TR1506 and IC1510 form a rapid charge circuit to charge the 15mF ground capacitor to the 3V normal operating level at power-up.

The capacitor voltage is compared with the 3V voltage control loop reference at IC1509b. If the capacitor voltage is low, the three-terminal self limiting regulator is turned full on via TR1506. When the capacitor voltage reaches the 3V reference level, the comparator circuit switches the regulator off and D1518 is reverse biased.

When dc bias is on, the pre-charge circuit is held off via $\overline{\text{BIE}}$ going low and overriding the 3V reference via D1517. With bias off and the ground capacitor C001 charged, the circuit regulates the 3 volts to within ±0.2V.

7.4.5 Rail Isolator

TR1510, D1509, TR1509 and D1510 form a level-dependent switch. At power-up, the 3245 ±12V option supplies are used to enable the 3220A/1 auxiliary ac power to be relay-switched using two rear panel mounted reed relays.
When the ±15V B rails power up, the level-dependent switch is held off, isolating the 3245 ±12V supplies from the 3220A/1 with the auxiliary ac power relay coil power now derived from the 3220A/1 ±15V B supplies. For a controlled start up and turn off, the auxiliary power relays are enabled when the 3245 reset line $\overline{\text{BRST}}$ becomes false via RL1501 and TR1501.

7.4.6 BVR Latch

The Bias Voltage Ready BVR signal becomes false if an excessive voltage drop occurs across the Unknown coil, which would cause the Source current regulator to saturate and give gross reading errors. BVR failure is detected by a comparator circuit, situated in the Source circuit, which feeds a current signal (Bias Voltage Monitor) BVM to the opto-coupler diode at IC1504 pin 6 when an over-voltage occurs. The opto-transistor forces BVR low and TR1508 is turned on by the opto-diode current which sets the latch IC1511b, "freezing" the occurrence of an over-voltage. The latch is reset by software control using the (Bias Voltage Arm) BVA control signal just prior to the next measurement or if any measurement parameter (AC level, bias level, etc) is changed by the user.

7.5 SINK CIRCUIT (Board prefix 14)

Component layout: Fig. 11.5. Circuit diagram: Fig. 11.6.

The Sink current regulator circuit consists of four identical power stages, A, B, C & D, each working up to 5Adc. Power Stage A is described in detail.

The current is sensed using the 0.1-ohm chassis-mounted power resistor R010 in the emitter circuit of the power Darlington TR005. The "current" signal is fed back to the operational amplifier IC1408 to provide series feedback to raise the ac output impedance of the power Darlington. The VMOS FET TR1404 buffers the IC amplifier output stage.

7.5.1 DC Control Amplifier

The output current signal of each 5A stage is summed by the dc control amplifier IC1404 which provides a mean dc reference for all four 5A stages. Current limiting is provided by the zener diode D1402 clamping the dc drive level, which is set by R1430 to give 5.5A average from each power stage.

7.5.2 Reference Circuit

Bias level data, received from the Auxiliary board, is converted into an analog reference voltage at IC1402 output via the DAC IC1401. IC1409 provides a precision 5V reference for the DAC and the 3V reference for the voltage control loop via R1411, R1473 and R1436.

The analog reference is fed into the dc control amplifier as a reference current via R1407.
The 5V reference is inverted by IC1403 to give "quiet" ±5V analog rails to the offset trim circuit R1405, R1406.

7.5.3 Fuse Monitor

To prevent a large current-hogging situation should a power transistor fail short-circuit, and to ease servicing and test by partitioning the circuits, each 5A stage is fuse protected in the collector of the power Darlington.

If a fuse fails, IC1410 compares the collapsed voltage of the failed 5A stage with a 2V reference. Fuse Sink (FSK) logic line will go low, initiating a "20A UNIT FUSES" message at the 3245.

7.5.4 Protection

If the main power should be removed while bias is on, the 3220A/1 will abruptly turn off the bias current as BIE and bias data are cleared by the system restart $\overline{\text{RST}}$.

The energy stored in the inductor is then dissipated safely by the Sink power stage. With the collapse of the bias current, the coil back-emf forces the voltage at the E terminal negative until clamped by the power diode D002 (mounted on the Source Fuse Panel) to the 20A supply negative rail (COM B). The coil current then charges the ground capacitor C001 from the 3V steady state condition to about 4.5V. At this point the Sink regulator is turned on by TR1405 transistor comparator, turning on the dc control amplifier IC1404. The Sink power stages turn full on, clamping the inductor voltage to a safe level. D1403 power diode ensures the bulk of the inductor current is bypassed, so preventing it from flowing through the 3245 I terminal circuit.

7.6 SOURCE CIRCUIT (Board prefix 13)

Component layout: Fig. 11.7. Circuit diagram: Fig. 11.8.

7.6.1 Power Stages

The 5A power stages and dc summing amplifier are similar to the Sink circuit but using transistors of opposite polarity. See Sink circuit description (section 7.5).

7.6.2 Voltage Control

TR1303, TR1304 form a long tail pair differential error amplifier for the voltage control of the Sink current regulator. The voltage across the ground capacitor is compared by TR1303, TR1304 with the 3V reference (generated from the Sink circuit). The amplifier error signal provides the reference signal to enable the Source to follow the current demanded by the Sink.

7.6.3 Bias Hold Off

The Source is inhibited by the (Bias Current Enable) $\overline{BIE}$ line becoming false, turning on TR1305, which holds off the voltage control amplifier through TR1301 and TR1302.

7.6.4 Current Status Monitor

The point at which the bias current has reached the correct level is detected by monitoring the derivative of the error signal at the Source current summing amplifier. When the bias error is within a few mA of the set level, the (Bias Current Enable) line BIE becomes true.
After buffering by IC1306a, the error signal is fed to the derivative circuit IC1308a, IC1306b. IC1308b provides a low-pass filter to remove noise from the highly amplified differentiated error signal. The filtered derivative signal is detected by the window comparator IC1309 c and d to produce a current output (BIM) to the opto-isolator circuit, situated on the Auxiliary board, whenever Bias Status is false.

7.6.5 Excess Voltage Monitor

Excess voltage drops are detected at the Source circuit by IC1309b. The

8 DISMANTLING

WARNING

> For personal safety, and to prevent possible damage to components, always allow 1 or 2 minutes from switch-off for reservoir capacitors to discharge. Check that all rail potentials have decayed before working on the circuits.

On rear lip of the top cover, turn 2 screws (using a 4mm a/f wrench or screwdriver, according to type fitted) counter-clockwise until a resistance is felt (do NOT attempt to remove them). Raise rear lip slightly and push the cover forward to clear front lip. Remove cover. A similar procedure applies for removal of the bottom cover, if this is necessary.

With top and bottom covers removed, 4 screws are visible which can be removed to release the front or the rear panel. DO NOT remove front and rear panels at one time or the assembly will collapse.

If, for any reason, leads are unsoldered or push-on connectors removed, the greatest care must be taken to ensure that they are replaced correctly. Refer to Figures 8.1, 8.2 and 8.3.

WARNING

> Leads replaced incorrectly can render the instrument dangerous to users and result in serious damage to the circuits.

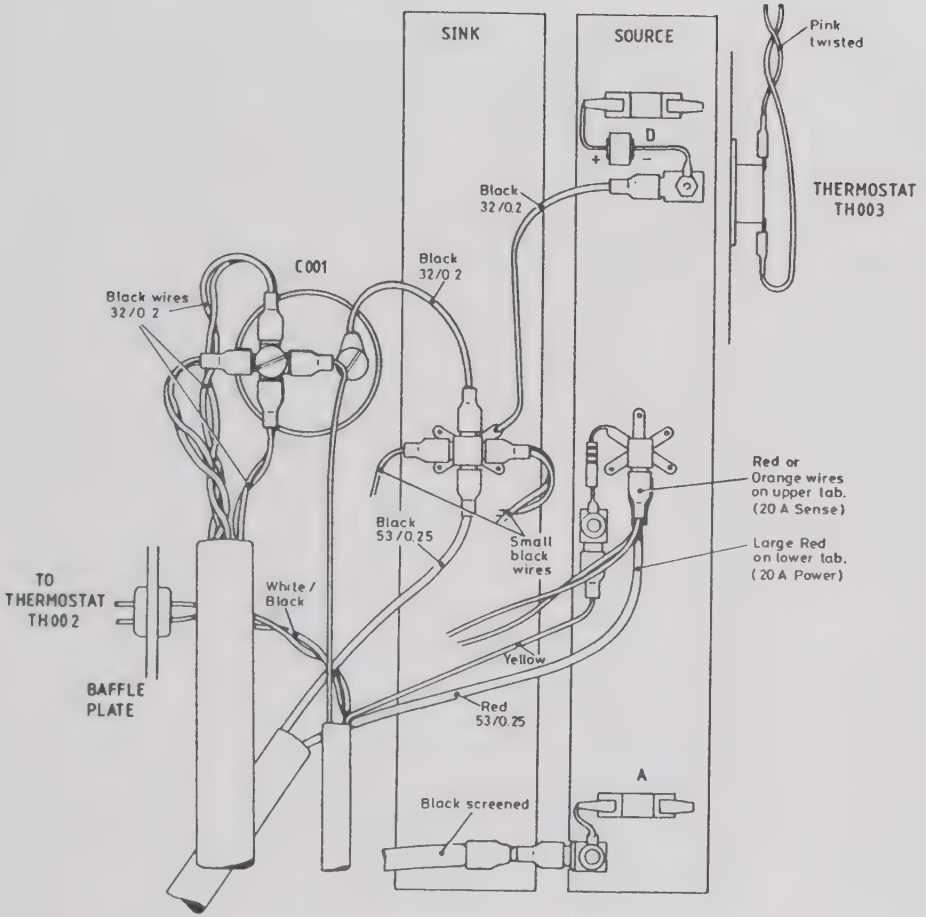


Fig. 8.1 Connections to Source & Sink Assemblies

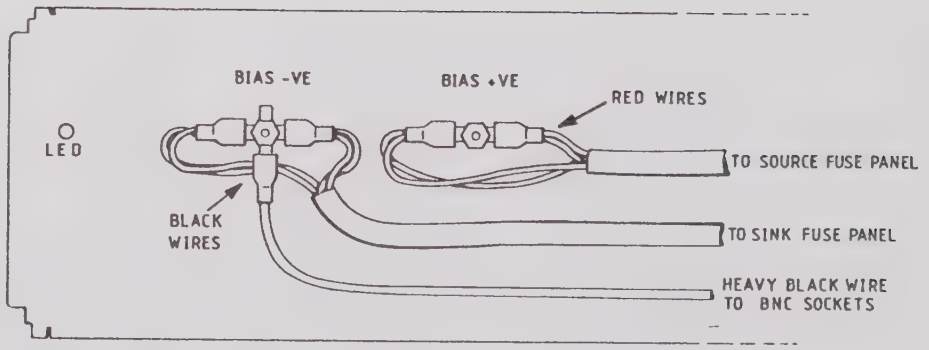


Fig. 8.2 Connections from Source & Sink to Front Panel (Viewed from above)

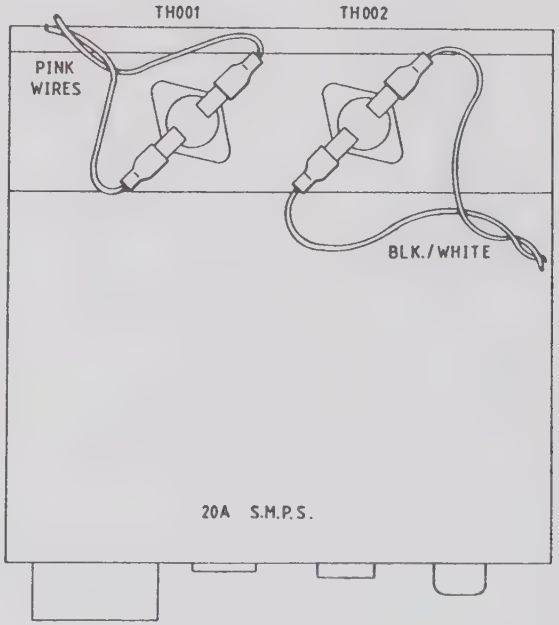


Fig. 8.3 Connections to TH001 a 002

9 TEST EQUIPMENT REQUIRED

Item 1 Power Variac, 500VA, adjustable from nominal line voltage to -15% of nominal.

Item 2 Multimeter covering 50µA to 10A dc and 0 to 20V dc to 1% accuracy.

Item 3 General-purpose DVM covering 0V to 20V dc with 10mV resolution.

Item 4 10A Shunt (20A short term) at 100mV.

Item 5 Precision DVM to measure 200mV dc with 10µV resolution and 100mA to 1A dc with 10µA resolution.

Item 6 Air-cored coil, 10mH at 30kHz.
Maximum volt drop at 20A dc (inc. leads): 5V.
Switched polystyrene capacitor to parallel tune the coil for an apparent inductance of 100mH ±1% at 10kHz. Value selected empirically by measuring the coil + capacitor on the 3245.

Item 7 Air-cored coil, 785µH ±1% at 100kHz.
Maximum volt drop at 20A dc (inc. leads): 5V.

Item 8 Test leads as required (see text).

Item 9 22Ω ±5% 5W resistor.

10 SETTING-UP PROCEDURES

10.1 GENERAL INFORMATION

A Although up to five 20A Bias Units type 3220A/1 can be controlled simultaneously by one Precision Inductance Analyzer type 3245, for maintenance purposes each 3220A/1 must be separated from any other 3220A/1's.

B On the Sink and Source sub-assemblies, the Common A and Common B lines are not at ground potential and must not have any direct connection to any chassis or ground termination. When fault-finding with an oscilloscope, isolate the oscilloscope from ground by using a power isolating transformer. This allows oscilloscope measurements to be made with reference to the Common A and B potentials.

C For personal safety, and to prevent possible damage to components, always allow 1 or 2 minutes from switch-off (on 3245 and 3220A/1) for reservoir capacitors to discharge. Check that all rail potentials have decayed before working on the circuits.

D For most tests, access will be required to the top of the 3220A/1 while it remains connected to a 3245. To achieve this, place the 3220A/1 beside, or on top of, the 3245 and make up extended BNC-BNC leads to link the two red and the two orange connectors on the instruments. Also use a longer 25-way ribbon cable, with D-type connectors each end, for the rear connection from the 3220A/1 to the 3245 Interface. (Users with more than one Bias Unit will find the cable supplied can be used).

E If it should be required to switch on a 3220A/1, for test purposes, without linking it to a 3245, this can be achieved using 10-volt and 24-volt dc supplies. Disconnect SK002 from the Auxiliary board and, using a suitable connector, apply 10V between pins 3 and 4 and 24V between pins 5 and 6 (in both cases the polarity is unimportant).

10.2 PRELIMINARY TESTS

Check that the selector switches on the rear panel are set correctly to suit the local supply nominal voltage.

Connect the 3220A/1 to the 500VA Variac (item 1) set for an output of 10% below nominal voltage (ie at 207V or 103V).

Using heavy-gauge leads (53 x 0.3mm min), connect the Multimeter (item 2), set to 10A dc, across the 3220A/1 bias terminals, linking each terminal to its associated sense terminal.

Connect the 3220A/1 to a 3245 (as in 10.1, D). Switch on the Variac and the 3245. The fan in the 3220A/1 should run at speed, reducing noticeably when the time delay relay (RL 004) operates after some 10 seconds, introducing a ballast resistor. On some models, in place of the relay, a lamp adjacent to R001 should initially light brightly and, as it diminishes to a glow, the fan speed reduces. The earliest models, with slightly different fan motor characteristics, have neither lamp nor delay relay. Select NORMAL, Hold, Single (Bias will be OFF). Key in CODE 3, Enter to select range 3.

10.3 FUNCTIONAL TESTS

10.3.1 Fan Regulation

Connect a test link across thermostat TH001 (mounted above the 20A Supply, adjacent to left-hand side panel) and check that the fan speed increases. Repeat this test with the link across TH003 (mounted on the rear of the Source heat sink assembly). Remove the test link.

10.3.2 Rail Isolator

Switch off 3245. Connect DVM (item 3) +ve lead to D09 anode and -ve lead to D28 anode, located on the Auxiliary board. Switch on 3245. Check that the 3220A/1 has powered up and that the DVM reading falls to less than 100mV.

10.3.3 Power Supplies

Transfer the DVM connections to the 20A supply: -ve to the Sink star terminal and +ve to the Source star terminal. The reading should be between 12.5 and 14.0V. (Power input to the 3220A/1 for all tests, is via the Variac at 10% below normal voltage).

Check that the Power LED on the 3220A/1 front panel is illuminated. With the DVM, check the ±15VB supplies at the Auxiliary board test points. All four, measured relative to their respective 0V lines - NOT to ground - should be between 14.2 and 15.8V. Switch off 3245.

10.3.4 Pre-charge Functional Test

Connect the DVM across the neutral capacitor C001 (15mF, mounted over Sink assembly): -ve to Sink star terminal and +ve to screen connections of the lower red BNC socket. Switch on the 3245 and check that the 3220A/1 starts up with between 2.8 and 3.3V rapidly established across C001. Adjust R73 at the rear of the Sink board for an initial value of 3 to 3.2V at the capacitor.

Set the 3245 for 1.6A dc, Bias ON, and check that the 10A meter reads 1.6A ±10% and that C001 voltage has not changed by more than ±0.1V. Switch off the 3245 and disconnect the DVM.

10.3.5 Bias Data Lines and BIE

Switch on 3245 and set the Multimeter at 3220A/1 bias terminals to 10mA dc range. The leakage current should not exceed 0.5mA.
Change the Multimeter to 1A dc range and, on 3245, select 0.2A dc, Bias ON. The reading should be 200mA ±1mA. If necessary, adjust R1406 (centre preset in Sink board).

10.3.6 Bias Power Monitor

Select Bias OFF and disconnect the Variac from the ac power supply. Remove the 6A HRC fuse (rear panel). Reconnect the Variac. The 3245 should show 20A UNIT: NO POWER. Disconnect Variac from ac supply, replace 6A fuse.

10.3.7 Bias Fuses Correct (BFC)

Reconnect Variac. Change Multimeter to 10A range. Select 3.2A dc, Bias ON. Momentarily remove the 6.3A fuse from fuseholder A on Sink fuse board and check the message ⚠ 20A UNIT FUSES ⚠ appears, the Bias turning off automatically. Replace the fuse, turn bias ON, ensure message extinguishes. Repeat the procedure for each of the 6.3A fuses on the Sink and Source fuse boards.

10.3.8 Bias Temperature Ready (BTR)

With Bias ON, remove one lead from thermostat TH002, mounted above the 20A power supply near to the Auxiliary board. Check the message ⚠ 20A OVER TEMP ⚠ appears, the Bias turning off automatically. Replace the thermostat connection, turn bias ON, and check that the message extinguishes. Turn bias OFF.

10.3.9 Bias Voltage Ready (BVR)

Remove heavy leads to Multimeter and connect 22Ω 5W resistor (item 9) across the 3220A/1 bias terminals. Select 200mA and turn bias ON. Ensure that DC CURRENT NOT SET message extinguishes after a few seconds. Increase the current to 400mA and ensure that DC CURRENT NOT SET appears, followed by EXCESS VOLTAGE DROP. Return current setting to 200mA within 10 seconds and ensure that the messages extinguish. Turn bias OFF.
Disconnect 22Ω resistor and reconnect Multimeter, set to 10A range.

10.3.10 Bias Current Ready (BIR)

Select 0.2A dc and Bias ON. Repeatedly switch the current setting between 0.2A and 0.3A and back again. At each transition, check that the message DC CURRENT NOT SET appears for about 1 second before extinguishing.

10.3.11 Trip Operation

Set Bias to 6.4A. Momentarily remove the heavy-gauge lead from the +ve bias terminal. Replace the lead, check that the current has been turned off, and remains off, and that the message SAFETY: BIAS TURNED OFF is displayed. Select Bias ON and check that current is restored to 6.4A nominal. Select Bias OFF.

10.3.12 Source and Sink Current Limits

These are factory set using special test equipment and will not normally require adjustment unless one of the power stage current sensing resistors has been changed. If necessary the current limit setting for any individual stage can be checked as follows:

For either the Source or Sink sub-assembly, remove all 6.3A fuses except for the one stage to be checked. With the multimeter set to the 10A range, set bias current to 1A and turn bias ON. Before the current has reached a steady value on the multimeter, start to increment the set value by repetitively pressing and releasing the ▲ button. The current level will continue to increase until the current limit for the stage under test is reached. This should lie between 5.3 and 5.8 Amps for each stage. If it is necessary to adjust either limit (R1430, nearest to rear on Sink, or R1339 on Source) then all four stages on the sub-assembly concerned should be checked.

10.3.13 DC Current Set Up

Transfer the heavy-gauge leads from the Multimeter to the terminals of the 20A shunt (item 4). Plug the shunt directly into the DVM terminals and set the DVM to volts dc.

NOTE 1 To minimize self-heating errors, avoid running the shunt above 10A for longer than necessary. Do not run at 20A for more than 1 minute continuous operation. Allow 3 minutes cooling time if this maximum duration is reached. At 12A the running time may be extended to 3 minutes.

NOTE 2 Do not run 3220A/1 with inlet air temperature greater than 30°C while setting-up the dc current. In particular, avoid placing the unit close to the solid back of a test bench, which can result in the heated exhaust air re-entering the inlet. The 3220A/1 self-heating is minimized by using the external shunt as a load.

Set Bias to 12.8A and select Bias ON. Allow up to 10 seconds for the current to settle to a steady value. The DVM should read 128mV ±120μV. If necessary, adjust preset R1409 (nearest to front on Sink board). To avoid self-heating errors, reduce Bias to 0.2A as soon as this reading is obtained.

If necessary, repeat the adjustment to R1406 (substituting the Multimeter by the DVM + Shunt), as described in the second paragraph of 10.3.5, followed by a repetition of the R1409 adjustment at 12.8A, until both are correct.

10.3.14 Bias Current Accuracy

With the 20A shunt still connected, and the Precision DVM (item 5) across it, check that 3245 is in NORMAL mode with selections Hold (Range 3 selected), Single, Slow, L, D, Series, 10kHz, 1V ac, 200mA dc, Bias ON.

Allow up to 10 seconds for the current to settle. The Precision DVM should read within 0.00195 to 0.00205V. Repeat for each current setting and test limit given in table 10.1.
Currents exceeding 10A should be selected for as short a duration as possible, up to a maximum of 1 minute (see NOTE 1 & NOTE 2 in 10.3.13).

TABLE 10.1

Setting Current	DVM Readings in mV	
	Minimum	Maximum
200mA	1.95	2.05
300mA	2.94	3.06
400mA	3.94	4.06
500mA	4.93	5.07
600mA	5.93	6.07
700mA	6.92	7.08
800mA	7.92	8.08
1.0A	9.90	10.09
1.5A	14.88	15.12
1.6A	15.88	16.12
3.1A	30.80	31.2
3.2A	31.80	32.2
6.3A	62.64	63.36
6.4A	63.64	64.36
12.7A	126.32	127.65
12.8A	127.32	128.65
20.0A	198.96	201.04

Remove the 20A shunt and link the Bias terminals.

Set the 3245 to 20A Bias ON.

Connect DVM -ve lead to the Sink star terminal - COM (B) - and the +ve lead to the TR05 side of Sink Fuse A. If necessary, adjust R73, at the rear of the Sink board, to obtain a reading of between 3 and 3.05V.

Repeat the check on the power transistor side of Sink Fuses B, C and D, making further slight adjustments to R73 if necessary.

Finally, switch Bias OFF and check that the reading (at any one of the above four fuses) does not increase to more than 3.4V.

10.4 ACCURACY TESTS

Replace 3220A/1 top cover and place the 3245 above it. Re-fit all four short BNC-BNC leads and the short ribbon cable.

10.4.1 Rdc Open-Circuit Error

Select Main Index, NORMAL, Rdc, Auto, Rep and Slow. The 3245 should read open circuit resistance error or greater than 150kΩ

10.4.2 Measurement Accuracy

SAFETY WARNING

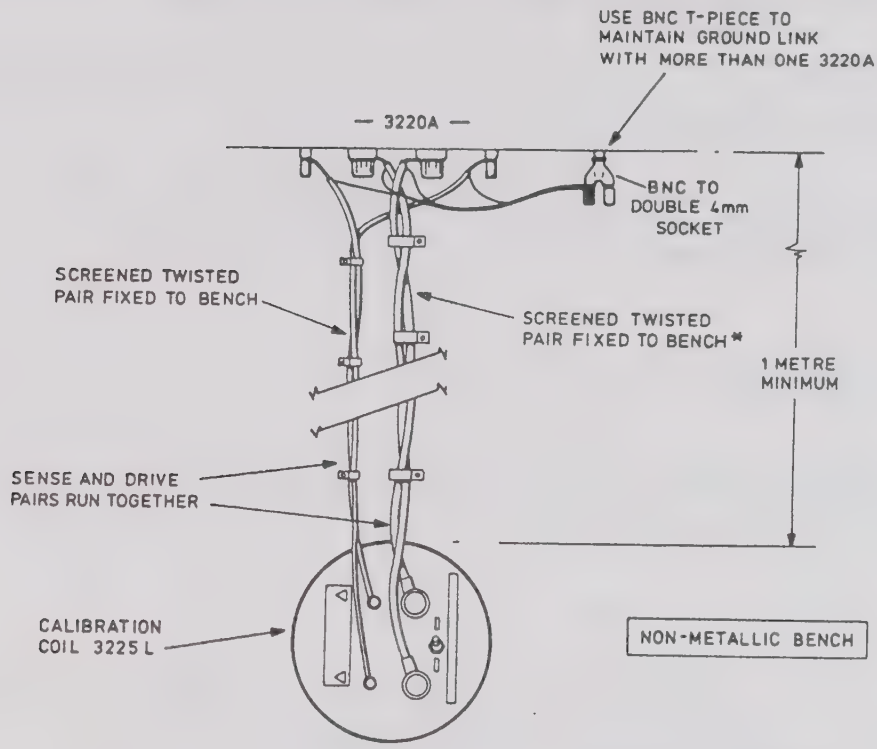
> The back-emf from the test inductor may be LETHAL.
> Always ensure that the direct current is at zero before disconnecting the inductor.

IN ALL THE FOLLOWING TESTS, KEEP LEAD DISTURBANCE TO THE ABSOLUTE MINIMUM.

Before carrying out the following, link the Bias terminals together and run the 3220A/1 for five minutes at 20A.

Set the 3245 to 1V, 30kHz. Carry out a normal open-circuit trim (with the Bias +ve drive and +ve sense leads removed from the coil and linked together) followed by a normal short-circuit trim (with a heavy link across the coil drive terminals).

Make 4-terminal connections to the 3225L Calibration Coil as shown below.


USE BNC T-PIECE TO MAINTAIN GROUND LINK WITH MORE THAN ONE 3220A
— 3220A —
BNC TO DOUBLE 4mm SOCKET
SCREENED TWISTED PAIR FIXED TO BENCH
SCREENED TWISTED PAIR FIXED TO BENCH*
1 METRE MINIMUM
SENSE AND DRIVE PAIRS RUN TOGETHER
CALIBRATION COIL 3225 L
NON-METALLIC BENCH
*SEE TABLE 1 FOR WIRE SIZE

ARRANGEMENT FOR CALIBRATION AND MEASUREMENT

Set 3245 to Main Index, Ext Bias Calibrate, Cal at Selected Freq. Set coil switch to Low Z when prompted by the 3245, and press Trigger. Without disturbing the test set-up, wait for the 3245 to carry out the low impedance calibration measurements and, when it prompts, set coil switch to High Z and again press Trigger.

On completion of the calibration procedures, replace the Calibration Coil by the 10mH Air-cored coil (Item 6). Set 3245 to Normal and note the no-bias values of L and D. Set 3245 to 3A, Bias ON.

Check that the L and D readings do not change by more than the amounts shown in Table 10.2 for each current setting at 30kHz. When testing above 10A, allow the 3220A/1 1 minute to heat up before making any measurements.

Set 3245 to 100kHz. Replace the 10mH coil by the Calibration Coil. Repeat the O/C and S/C trims described above for 100kHz 'Cal at Selected Freq' operation.

Replace the Calibration Coil by the 785µH coil (Item 7). Check that the accuracy is within the appropriate limits shown in Table 10.2.

Replace the 785µH coil by the Calibration Coil (3225L). Set 3245 to 10kHz and repeat the O/C Trim and S/C Trim. Set EXT BIAS CALIBRATE to the Spot trim mode and carry out a Low Z calibration procedure as described earlier. When the 3245 prompts for High Z, replace the Calibration Coil by the 10mH/100mH coil (Item 6), set to 10mH. Press Trigger to continue the High Z calibration routine.

On completion of the calibration, set the test coil to 100mH and record L and D values at 0 bias. Set 3245 to 20A and repeat the accuracy test against the limit shown in Table 10.2 for 10kHz.

TABLE 10.2

FREQ	10kHz	30kHz	100kHz
COIL (Nom value)	100mH	10mH	785µH
BIAS LEVEL			
3A	N/A		
11A	N/A		
		±0.1mH	±8µH
16A	N/A		
18A	N/A		
20A	±2mH		

ALL D LIMITS: <0.04

Set 3245 to Bias OFF. Wait for bias to reduce to zero and remove all test equipment.

11 3220A/1 - COMPONENTS LIST

11.1 INTERFACE PCB BCI-A

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R201	4k7	2	150ppm	S.I.L.	A.Bradley 910A 472
R202	1k	5		Metal Film	Mullard SFR25
R203	1k	5		Metal Film	Mullard SFR25
R204	Not fitted				
R205	10k	5		Metal Film	Mullard SFR25
R206	10k	5		Metal Film	Mullard SFR25
R207	3k4	1	100ppm	Metal Film	A.Bradley FC55
R208	100R	5		Metal Film	Mullard SFR25
R209	Not fitted				
R210	10k	5		Metal Film	Mullard SFR25
R211	39R	5		Metal Film	Mullard SFR25
R212	180k	5		Metal Film	Mullard SFR25
R213	12k	5		Metal Film	Mullard SFR25
C201	100n		63V	Ceramic Disc	Siemens B37449
C202	100n		63V	Ceramic Disc	Siemens B37449
C203	10µ		25V	Electrolytic	Mullard 030-36109
C204	10µ		25V	Electrolytic	Mullard 030-36109
C205	680n	5	63V	Polyester	Wima MKS4 PCM10
C206	100n		63V	Ceramic Disc	Siemens B37449
C207	1n	10	63V	Ceramic	Mullard 630-19102
C208	Not fitted				
C209	220n		10V	Ceramic Disc	ITT TD16/K3 10V
C210	1n	10	63V	Ceramic	Mullard 630-19102
IC201	SN74LS273N				Texas
IC202	SN74LS273N				Texas
IC203	DM81LS95N				N.S.C
IC204	SN74LS33N				Texas
IC205	SN74LS138N				Texas
IC206	SN74LS32N				Texas
IC207	LM339N				N.S.C

(3220A/1 INTERFACE PCB BCI-A - Continued)

Ref	Description	Supplier & Type No.
D201	1N4002	I.R.
TR201	VN2222L	Siliconix
TR202	VN2222L	Siliconix
TR203	VN2222L	Siliconix
TR204	BC184	Texas
RL201	Reed Relay 5V coil with diode	Pickering 87-1C-5/7D
RL202	" " " " " "	Pickering 87-1C-5/7D
PL201	64-way Indirect male connector	Vero 17-2876D
PL202	Jack Plug 3.5mm 3 Pole unscreened	Rendar R223,000,00
SK201	25-way D-type sub-min socket	FCT (Multipulse) F25SM/B/F/D
SK202	Jack socket 3.5mm 3 Pole unscreened	Rendar R363,000,00

11.2 3220A/1 - SOURCE PCB

Ref	Value	Tol(%)	Rating	Type	Supplier & type No.
R1301	100R	5		Metal Film	Mullard SFR25H
R1302	100R	5		Metal Film	Mullard SFR25H
R1303	1k	5		Metal Film	Mullard SFR25
R1304	1k	5		Metal Film	Mullard SFR25
R1305	1k	5		Metal Film	Mullard SFR25
R1306	1k	5		Metal Film	Mullard SFR25
R1307	470R	5		Metal Film	Mullard SFR25
R1308	470R	5		Metal Film	Mullard SFR25
R1309	470R	5		Metal Film	Mullard SFR25
R1310	470R	5		Metal Film	Mullard SFR25
R1311	560R	5		Metal Film	Mullard SFR25
R1312	560R	5		Metal Film	Mullard SFR25
R1313	560R	5		Metal Film	Mullard SFR25
R1314	560R	5		Metal Film	Mullard SFR25
R1315	270R	5		Metal Oxide	Electrosil FP1
R1316	270R	5		Metal Oxide	Electrosil FP1
R1317	270R	5		Metal Oxide	Electrosil FP1
R1318	270R	5		Metal Oxide	Electrosil FP1
R1319	1k	5		Metal Film	Mullard SFR25
R1320	1k	5		Metal Film	Mullard SFR25
R1321	1k	5		Metal Film	Mullard SFR25
R1322	1k	5		Metal Film	Mullard SFR25
R1323	2k4	1	100ppm	Metal Film	Allen Bradley FC55
R1324	2k4	1	100ppm	Metal Film	Allen Bradley FC55
R1325	2k4	1	100ppm	Metal Film	Allen Bradley FC55
R1326	2k4	1	100ppm	Metal Film	Allen Bradley FC55
R1327	2k4	1	100ppm	Metal Film	Allen Bradley FC55
R1328	2k4	1	100ppm	Metal Film	Allen Bradley FC55
R1329	2k4	1	100ppm	Metal Film	Allen Bradley FC55
R1330	2k4	1	100ppm	Metal Film	Allen Bradley FC55
R1331	3k3	5		Metal Film	Mullard SFR25
R1332	3k9	5		Metal Film	Mullard SFR25
R1333	8k2	5		Metal Film	Mullard SFR25
R1334	100R	5		Metal Film	Mullard SFR25
R1335	100R	5		Metal Film	Mullard SFR25
R1336	1k5	2		Metal Oxide	Electrosil TR4

(3220A/1 SOURCE PCB - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R1337	680R	5		Film	Mullard SFR25H
R1338	27k	2		Metal Oxide	Electrosil TR4
R1339	500R	10		Variable Cerm	Allen Bradley E4A
R1340	3k0	2		Metal Oxide	Electrosil TR4
R1341	10R	5		Film	Mullard SFR25
R1342	10k	5		Film	Mullard SFR25
R1343	10M	5		Metal Glaze	Mullard VR25
R1344	470k	5		Film	Mullard SFR25
R1345	470k	5		Film	Mullard SFR25
R1346	22k	2		Metal Oxide	Electrosil TR4
R1347	2k2	2		Metal Oxide	Electrosil TR4
R1348	2k2	2		Metal Oxide	Electrosil TR4
R1349	22k	2		Metal Oxide	Electrosil TR4
R1350	22k	5		Film	Mullard SFR25
R1351	100k	5		Film	Mullard SFR25
R1352	100k	5		Film	Mullard SFR25
R1353	22k	5		Film	Mullard SFR25
R1354	4k7	5		Film	Mullard SFR25
R1355	4k7	5		Film	Mullard SFR25
R1356	4k7	5		Film	Mullard SFR25
R1357	4k7	5		Film	Mullard SFR25
R1358	4k7	5		Film	Mullard SFR25
R1359	160k	1	100ppm	Metal Film	Allen Bradley FC55
R1360	110k	1	100ppm	Metal Film	Allen Bradley FC55
R1361	Not fitted				
R1362	4k7	5		Film	Mullard SFR25
R1363	10k	5		Film	Mullard SFR25
R1364	10k	5		Film	Mullard SFR25
R1365	10k	5		Film	Mullard SFR25
R1366	10k	5		Film	Mullard SFR25
R1367	10k	5		Film	Mullard SFR25
R1368	2k7	5		Film	Mullard SFR25
R1369	10k	5		Film	Mullard SFR25
R1370	180k	5		Film	Mullard SFR25

(3220A/1 SOURCE PCB - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
C1301	220µ		16V	Electrolytic	Mullard 031-35221
C1302	220µ		16V	Electrolytic	Mullard 031-35221
C1303	Not fitted				
C1304	100p	10	500V	Ceramic Disc	ITT CD08/N3300
C1305	1n	10	63V	Polyester	Wima FKS2
C1306	1n	10	63V	Polyester	Wima FKS2
C1307	1n	10	63V	Polyester	Wima FKS2
C1308	1n	10	63V	Polyester	Wima FKS2
C1309	100n	10	63V	Polyester	Wima MKS2
C1310	100n	10	63V	Polyester	Wima MKS2
C1311	100n	10	63V	Polyester	Wima MKS2
C1312	100n	10	63V	Polyester	Wima MKS2
C1313	1µ	10	50V	Polyester	Wima MKS2
C1314	4n7	10	100V	Polyester	Wima FKS2
C1315	4n7	10	100V	Polyester	Wima FKS2
C1316	1n	10	100V	Ceramic	Mullard 630-19102
C1317	1n	10	100V	Ceramic	Mullard 630-19102
C1318	Not fitted				
C1319	220µ		16V	Electrolytic	Mullard 031-35221
C1320	10µ	20	35V	Tantalum	ITT TAG
C1321	Not fitted				
C1322	1n	10	100V	Ceramic	Mullard 630-19102
IC1301	LF351N				National
IC1302	LF351N				National
IC1303	LF351N				National
IC1304	LF351N				National
IC1305	LM308AN				National
IC1306	LF353N				National
IC1307	Not fitted				
IC1308	LF353N				National
IC1309	LM339N				National
IC1310	LM339N				National

(3220A/1 SOURCE PCB - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
D1301	1N4448			Diode	ITT
D1302	1N4448			Diode	ITT
D1303	1N4448			Diode	ITT
D1304	BZX79 C6V2			Zener Diode	Mullard
D1305	BZX79 C9V1			Zener Diode	Mullard
D1306	Not fitted				
D1307	BZX79 C6V2			Zener Diode	Mullard
D1308	Not fitted				
D1309	1N4148			Diode	I.R.
D1310	1N4148			Diode	I.R.
D1311	1N4148			Diode	I.R.
D1312	1N4148			Diode	I.R.
D1313	1N4148			Diode	I.R.
TR1301	BC214			Transistor	Texas
TR1302	BC214			Transistor	Texas
TR1303	BC184			Transistor	Texas
TR1304	BC184			Transistor	Texas
TR1305	VN2222L			Transistor	Siliconix
TR1306	VP0300M			Transistor	Siliconix
TR1307	VP0300M			Transistor	Siliconix
TR1308	VP0300M			Transistor	Siliconix
TR1309	VP0300M			Transistor	Siliconix
PL1301/TC1301	Link cable assembly				To WK Drg. DV3/25645
PL1302	6-way right-angle plug				Molex 22-05-7068
PL1303	6-way right-angle plug				Molex 22-05-7068
PL1304	6-way right-angle plug				Molex 22-05-7068
PL1305	6-way right-angle plug				Molex 22-05-7068

11.3 3220A/1 - SINK PCB

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R1401	10k	2		Metal Oxide	Welwyn MR4
R1402	10k	2		Metal Oxide	Welwyn MR4
R1403	3k	2		Metal Oxide	Welwyn MR4
R1404	3k	2		Metal Oxide	Welwyn MR4
R1405	1M	5		Metal Film	Mullard SFR25
R1406	2k	10		Variable Cerm	Allen Bradley E4A
R1407	4k7	1	25ppm	Metal Film	Allen Bradley FC55
R1408	22k			SIL Network	A. Bradley 909A 223
R1409	10k	10		Variable Cerm	Allen Bradley E4A
R1410	10k	5		Metal Film	Mullard SFR25
R1411	1k3	5		Metal Film	Mullard SFR25
R1412	Not fitted				
R1413	1k	5		Metal Film	Mullard SFR25
R1414	1k	5		Metal Film	Mullard SFR25
R1415	1k	5		Metal Film	Mullard SFR25
R1416	1k	5		Metal Film	Mullard SFR25
R1417	100R	5		Metal Film	Mullard SFR25
R1418	100R	5		Metal Film	Mullard SFR25
R1419	100R	5		Metal Film	Mullard SFR25
R1420	100R	5		Metal Film	Mullard SFR25
R1421	2k4	1	25ppm	Metal Film	Allen Bradley FC55
R1422	2k4	1	25ppm	Metal Film	Allen Bradley FC55
R1423	2k4	1	25ppm	Metal Film	Allen Bradley FC55
R1424	2k4	1	25ppm	Metal Film	Allen Bradley FC55
R1425	2k4	1	25ppm	Metal Film	Allen Bradley FC55
R1426	2k4	1	25ppm	Metal Film	Allen Bradley FC55
R1427	2k4	1	25ppm	Metal Film	Allen Bradley FC55
R1428	2k4	1	25ppm	Metal Film	Allen Bradley FC55
R1429	27k	2		Metal Oxide	Welwyn MR4
R1430	500R	10		Variable Cerm	Allen Bradley E4A
R1431	3k	2		Metal Oxide	Welwyn MR4
R1432	560R	5		Metal Film	Mullard SFR25
R1433	560R	5		Metal Film	Mullard SFR25
R1434	560R	5		Metal Film	Mullard SFR25
R1435	560R	5		Metal Film	Mullard SFR25

(3220A/1 SINK PCB - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R1436	5k1	5		Metal Film	Mullard SFR25
R1437	1k	5		Metal Film	Mullard SFR25
R1438	1k	5		Metal Film	Mullard SFR25
R1439	1k	5		Metal Film	Mullard SFR25
R1440	1k	5		Metal Film	Mullard SFR25
R1441	100R	5		Metal Film	Mullard SFR25H
R1442	100R	5		Metal Film	Mullard SFR25H
R1443	680R	5		Metal Film	Mullard SFR25H
R1444	5k6	5		Metal Film	Mullard SFR25
R1445	100k	5		Metal Film	Mullard SFR25
R1446	100k	5		Metal Film	Mullard SFR25
R1447	100k	5		Metal Film	Mullard SFR25
R1448	100k	5		Metal Film	Mullard SFR25
R1449	8k2	5		Metal Film	Mullard SFR25
R1450	270R	5		Metal Film	Mullard SFR25H
R1471	33k	5	1/4	Metal Film	Mullard SFR25
R1472	8k2	5	1/4	Metal Film	Mullard SFR25
R1473	2k	10		Variable Cerm	A.Bradley E4A
C1401	220µ		16V	Electrolytic	Mullard 031-35221
C1402	220µ		16V	Electrolytic	Mullard 031-35221
C1403	100n	10	63V	Polyester	Wima MKS2
C1404	Not fitted				
C1405	100n	10	63V	Polyester	Wima MKS2
C1406	100p	10	500V	Ceramic	ITT CD08/N3300
C1407	Not fitted				
C1408	1n	10	63V	Polyester	Wima FKS2
C1409	1n	10	63V	Polyester	Wima FKS2
C1410	1n	10	63V	Polyester	Wima FKS2
C1411	1n	10	63V	Polyester	Wima FKS2
C1412	100n	10	63V	Polyester	Wima MKS2
C1413	100n	10	63V	Polyester	Wima MKS2
C1414	100n	10	63V	Polyester	Wima MKS2
C1415	100n	10	63V	Polyester	Wima MKS2

(3220A/1 SINK PCB - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
IC1401	AD7541AJN				Analogue Devices
IC1402	LM308AN				National
IC1403	LF351N				National
IC1404	OP27GZ				P.M.I.
IC1405	LF351N				National
IC1406	LF351N				National
IC1407	LF351N				National
IC1408	LF351N				National
IC1409	9495CJ				Teledyne
IC1410	LM339N				National
D1401	HSC1001			Schottky Diode	Hewlett Packard
D1402	BZX79 C6V2			Zener Diode	Mullard
D1403	MR750			Diode Rectifier	Motorola
D1404	1N4148			Diode	I.R.
D1405	BZX79 C4V7			Zener Diode	Mullard
D1406	1N4148			Diode	I.R.
D1407	1N4148			Diode	I.R.
D1408	1N4148			Diode	I.R.
D1409	1N4148			Diode	I.R.
D1410	1N4148			Diode	I.R.
D1411	1N4148			Diode	I.R.
D1412	1N4148			Diode	I.R.
D1413	1N4148			Diode	I.R.
TR1401	VN10LM			Transistor	Siliconix
TR1402	VN10LM			Transistor	Siliconix
TR1403	VN10LM			Transistor	Siliconix
TR1404	VN10LM			Transistor	Siliconix
TR1405	BC214			Transistor	Texas
PL1401/TC1401	Link cable assembly				To WK Drg. DV3/25655
PL1402	6-way right-angle plug				Molex 22-05-7068
PL1403	6-way right-angle plug				Molex 22-05-7068
PL1404	6-way right-angle plug				Molex 22-05-7068
PL1405	6-way right-angle plug				Molex 22-05-7068

11.4 3220A/1 - AUXILIARY PCB

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R1501	22k			SIL Network	A. Bradley 909A 223
R1502	470R	5		Film	Mullard SFR25
R1503	220R	5		Film	Mullard SFR25
R1504	10k	1	100ppm	Metal Film	Allen Bradley FC55
R1505	10k	5		Film	Mullard SFR25
R1506	10k	5		Film	Mullard SFR25
R1507	100R	0.5	100ppm	Metal Film	Allen Bradley FC55
R1508	100R	0.5	100ppm	Metal Film	Allen Bradley FC55
R1509	100R	0.5	100ppm	Metal Film	Allen Bradley FC55
R1510	100R	0.5	100ppm	Metal Film	Allen Bradley FC55
R1511	1k1	0.5	100ppm	Metal Film	Allen Bradley FC55
R1512	1k1	0.5	100ppm	Metal Film	Allen Bradley FC55
R1513	1k1	0.5	100ppm	Metal Film	Allen Bradley FC55
R1514	1k1	0.5	100ppm	Metal Film	Allen Bradley FC55
R1515	22k	5		Film	Mullard SFR25
R1516	22k	5		Film	Mullard SFR25
R1517	2k7	5		Film	Mullard SFR25H
R1518	Not fitted				
R1519	22k	5		Film	Mullard SFR25
R1520	Not fitted				
R1521	Not fitted				
R1522	Not fitted				
R1523	Not fitted				
R1524	Not fitted				
R1525	Not fitted				
R1526	Not fitted				
R1527	Not fitted				
R1528	10k	5		Film	Mullard SFR25
R1529	68k	5		Film	Mullard SFR25
R1530	10k	5		Film	Mullard SFR25
R1531	100k	5		Film	Mullard SFR25
R1532	270R	5		Film	Mullard SFR25
R1533	10M	10		Film	Mullard SFR25
R1534	Not fitted				
R1535	18k	5		Film	Mullard SFR25
R1536	1k	5		Film	Mullard SFR25

(3220A/1 AUXILIARY PCB - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R1537	22k	5		Film	Mullard SFR25
R1538	22k	5		Film	Mullard SFR25
R1539	100k	5		Film	Mullard SFR25
R1540	1k3	5		Film	Mullard SFR25
R1541	1M	5		Film	Mullard SFR25
R1542	10k	5		Film	Mullard SFR25
R1543	15k	5		Film	Mullard SFR25
R1544	15k	5		Film	Mullard SFR25
R1545	2k2	5		Film	Mullard SFR25
R1546	4k7	5		Film	Mullard SFR25
R1547	18k	5		Film	Mullard SFR25
R1548	220k	5		Film	Mullard SFR25
R1549	470k	5		Film	Mullard SFR25
R1550	47R	5		Film	Mullard SFR25H
C1501	680µ		40V	Electrolytic	Mullard 035-57681
C1502	680µ		40V	Electrolytic	Mullard 035-57681
C1503	680µ		40V	Electrolytic	Mullard 035-57681
C1504	680µ		40V	Electrolytic	Mullard 035-57681
C1505	33µ		25V	Electrolytic	WAYCOM WSQ-33-25-P
C1506	33µ		25V	Electrolytic	WAYCOM WSQ-33-25-P
C1507	33µ		25V	Electrolytic	WAYCOM WSQ-33-25-P
C1508	33µ		25V	Electrolytic	WAYCOM WSQ-33-25-P
C1509	220µ		16V	Electrolytic	Mullard 035-55221
C1510	220µ		16V	Electrolytic	Mullard 035-55221
C1511	220µ		16V	Electrolytic	Mullard 035-55221
C1512	220µ		16V	Electrolytic	Mullard 035-55221
C1513	47µ		10V	Electrolytic	Mullard 035-54479
C1514	Not fitted				
C1515	100n		63V	Ceramic	Siemens B37449
C1516	100n	10	63V	Polyester	Wima MKS2
C1517	100n		63V	Ceramic	Siemens B37449

(3220A/1 AUXILIARY PCB - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
IC1501	LM339N			Linear	National
IC1502	LM339N			Linear	National
IC1503	LM339N			Linear	National
IC1504	PC847			Opto-Coupler	Sharp
IC1505	LM317T			Regulator	National
IC1506	LM317T			Regulator	National
IC1507	LM337T			Regulator	National
IC1508	LM337T			Regulator	National
IC1509	LM324N			Linear	National
IC1510	LM317T			Regulator	National
IC1511	CD4013BE				RCA
IC1512	CD4001BE				RCA
IC1513	LF351N				National
D1501	1KAB10			Diode Block	I.R.
D1502	1KAB10			Diode Block	I.R.
D1503	1KAB10			Diode Block	I.R.
D1504	1KAB10			Diode Block	I.R.
D1505	1N4002			Diode Rect.	I.R.
D1506	1N4002			Diode Rect.	I.R.
D1507	1N4002			Diode Rect.	I.R.
D1508	1N4002			Diode Rect.	I.R.
D1509	1N4002			Diode Rect.	I.R.
D1510	1N4002			Diode Rect.	I.R.
D1511	Not fitted				
D1512	1N4002			Diode Rect.	I.R.
D1513	Not fitted				
D1514	Not fitted				
D1515	Not fitted				
D1516	Not fitted				
D1517	1N4148			Signal Diode	I.R.
D1518	1N4002			Diode Rect.	I.R.
D1519	1N4002			Diode Rect.	I.R.
D1520	1N4002			Diode Rect.	I.R.
D1521	Not fitted				

(3220A/1 AUXILIARY PCB - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
D1522	1N4148			Signal Diode	I.R.
D1523	Not fitted				
D1524	BZX79 C4V7			Zener Diode	Mullard
D1525	1N4148			Signal Diode	I.R.
D1526	1N4148			Signal Diode	I.R.
D1527	1N4148			Signal Diode	I.R.
D1528	1N4148			Signal Diode	I.R.
TR1501	VN10KM			Transistor	Siliconix
TR1502	BC184			Transistor	Texas
TR1503	VN2222LM			Transistor	Siliconix
TR1504	Not fitted				
TR1505	Not fitted				
TR1506	BC214			Transistor	Texas
TR1507	VN2222LM			Transistor	Siliconix
TR1508	BC214			Transistor	Texas
TR1509	BC184			Transistor	Texas
TR1510	BC214			Transistor	Texas
FS1501	Fuse 20x5mm 6.3A-F		Quick acting	Belling Lee L1427B	
FS1502	Fuse 20x5mm 1A-T		Slow-Blow	Beswick	
FS1503	Fuse 20x5mm 1A-T		Slow-Blow	Beswick	
FS1504	Fuse 20x5mm 1A-T		Slow-Blow	Beswick	
FS1505	Fuse 20x5mm 1A-T		Slow-Blow	Beswick	
PL1501	10-way Header 0.156"pitch				Panduit HLSS 156-10-X
PL1502	6-way Header 0.156"pitch				Panduit HLSS 156-6-X
PL1503	6-way right-angle wafer 0.1" pitch				Molex 22-05-7068
PL1504	26-way right-angle header				3M 3429-1302
RL1501	Reed Relay, 5V coil, with diode				Pickering 86-1A-5/1D
SK1501	16-pin IC socket ICE-163-S-TG				Robinson Nugent
SK1502	16-pin IC socket ICE-163-S-TG				Robinson Nugent
TS1501	MOXIE Temp. sensor				Microtherm TS3-57

11.5 3220A/1 - HEAT-SINK ASSEMBLIES (SOURCE & SINK)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R002	1k	5		Film	Mullard SFR25
R003	OR1	3		WH10	Welwyn
R004	OR1	3		WH10	Welwyn
R005	OR1	3		WH10	Welwyn
R006	OR1	3		WH10	Welwyn
R007	OR1	3		WH10	Welwyn
R008	OR1	3		WH10	Welwyn
R009	OR1	3		WH10	Welwyn
R010	OR1	3		WH10	Welwyn
R011	10R	5		Film	Mullard SFR25
R012	10R	5		Film	Mullard SFR25
R013	10R	5		Film	Mullard SFR25
R014	10R	5		Film	Mullard SFR25
R015	10R	5		Film	Mullard SFR25
R016	10R	5		Film	Mullard SFR25
R017	10R	5		Film	Mullard SFR25
R018	10R	5		Film	Mullard SFR25
R020	22k	5		Film	Mullard SFR25
C001	15m		16V	Electrolytic	Adv. Filmcap EP24
C004	Not fitted				
C005	47n		12V	Ceramic Disc	ITT TD08/K3
C006	47n		12V	Ceramic Disc	ITT TD08/K3
C007	47n		12V	Ceramic Disc	ITT TD08/K3
C008	47n		12V	Ceramic Disc	ITT TD08/K3
C009	47n		12V	Ceramic Disc	ITT TD08/K3
C010	47n		12V	Ceramic Disc	ITT TD08/K3
C011	47n		12V	Ceramic Disc	ITT TD08/K3
C012	47n		12V	Ceramic Disc	ITT TD08/K3
D002	MR750			Diode Rect.	Motorola
L001	10µH		6A	Insulated Plastic Sleeve	Ferroperm
L002	10µH		6A	Insulated Plastic Sleeve	Ferroperm
L003	10µH		6A	Insulated Plastic Sleeve	Ferroperm

(3220A/1 HEAT-SINK - Continued)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
L004	10µH		6A	Insulated Plastic Sleeve	Ferroperm
L005	10µH		6A	Insulated Plastic Sleeve	Ferroperm
L006	10µH		6A	Insulated Plastic Sleeve	Ferroperm
L007	10µH		6A	Insulated Plastic Sleeve	Ferroperm
L008	10µH		6A	Insulated Plastic Sleeve	Ferroperm
TR001	TIP645			Pwr Transistor	Texas
TR002	TIP645			Pwr Transistor	Texas
TR003	TIP645			Pwr Transistor	Texas
TR004	TIP645			Pwr Transistor	Texas
TR005	TIP640			Pwr Transistor	Texas
TR006	TIP640			Pwr Transistor	Texas
TR007	TIP640			Pwr Transistor	Texas
TR008	TIP640			Pwr Transistor	Texas
FS003	Fuse	20x5mm	6.3A	Quick blow	Belling Lee L1427B
FS004	Fuse	20x5mm	6.3A	Quick blow	Belling Lee L1427B
FS005	Fuse	20x5mm	6.3A	Quick blow	Belling Lee L1427B
FS006	Fuse	20x5mm	6.3A	Quick blow	Belling Lee L1427B
FS007	Fuse	20x5mm	6.3A	Quick blow	Belling Lee L1427B
FS008	Fuse	20x5mm	6.3A	Quick blow	Belling Lee L1427B
FS009	Fuse	20x5mm	6.3A	Quick blow	Belling Lee L1427B
FS010	Fuse	20x5mm	6.3A	Quick blow	Belling Lee L1427B
SK1302	6-way socket 6471. 0.1" pitch				Molex 22-01-2065
SK1303	6-way socket 6471. 0.1" pitch				Molex 22-01-2065
SK1304	6-way socket 6471. 0.1" pitch				Molex 22-01-2065
SK1305	6-way socket 6471. 0.1" pitch				Molex 22-01-2065
SK1402	6-way socket 6471. 0.1" pitch				Molex 22-01-2065
SK1403	6-way socket 6471. 0.1" pitch				Molex 22-01-2065
SK1404	6-way socket 6471. 0.1" pitch				Molex 22-01-2065
SK1405	6-way socket 6471. 0.1" pitch				Molex 22-01-2065

11.6 3220A/1 - CHASSIS (Including Front & Rear Panels)

Ref	Value	Tol(%)	Rating	Type	Supplier & Type No.
R001	Not fitted				
R021	OR47	10		Wire Wound	Welwyn W21
D001	HLMP/3401			Yellow LED	Hewlett Packard
D003	MR750			Diode	Motorola
D004	MR750			Diode	Motorola
D005	MR750			Diode	Motorola
FS001	Fuse 1.25"x.25"		6A	Fast HRC	Littelfuse 314006
FS002	Fuse 20x5mm		250mA-T	(250V)	Beswick TDC123
FS002	Fuse 20x5mm		500mA-T	(115V)	Beswick TDC123
LM001*	Lamp 12V		2.2W		Vitality MES987
PL001	Appliance Inlet, "Clip in"				Rendar R470,300,00
PL002/SK008	Interface connector				To WK Drg. DV2/25654
PL003	6-way connector .093"pitch 1261				Molex 03-09-2061
PL004	6-way connector .093"pitch 1261				Molex 03-09-2061
PSU001	Power Supply				Farnell G12/20A

* On some early models only.

(3220A/1 CHASSIS - Continued)

Ref	Description	Supplier & Type No.
RL001	Chassis Relay 12V ac coil	Omron 60-62
RL002	Reed Relay (Chassis mtg)	Pickering 60-1-A-12/777
RL003	Reed Relay (Chassis mtg)	Pickering 60-1-A-12/777
RL004	Not fitted	
SK001	10-way centreline connector .156" pitch	Brown Panduit CE156 F20-10
SK002	6-way centreline connector .156" pitch	Brown Panduit CE156 F20-6
SK003	Connector, 1261 6-way	Molex 03-09-1061
SK004	Connector, 1261 6-way	Molex 03-09-1061
SK005	Insulated Bulkhead Socket	Belling & Lee LX04-0503-ZZ005N
SK006	Insulated Bulkhead Socket	Belling & Lee LX04-0503-ZZ005N
SK007	Insulated Bulkhead Socket	Belling & Lee LX04-0503-ZZ005N
SK008	Insulated Bulkhead Socket	Belling & Lee LX04-0503-ZZ005N
SK009	Insulated Bulkhead Socket	Belling & Lee LX04-0503-ZZ005N
SK1503	6-way socket 0.1" pitch 6471	Molex 22-01-2065
SK1504	26-way connector socket 0.1" pitch	3M 3399-6000
SW001	Slider switch	Rendar R530,040,00
SW002	Slider switch	Rendar R530,040,00
T001	Power transformer	WK 4-385-5661
Terminal	Bias +	Belling & Lee L309/1/RED
Terminal	Bias -	Belling & Lee L309/1/BLACK
Terminal	Sense (+ve)	Belling & Lee E6020/1/RED
Terminal	Sense (-ve)	Belling & Lee E6020/1/BLACK
Fan Axial		Comair Rotron MC12T3H/032399

BNC-BNC Leads (4 per 3245-3220A/1)	To WK Drg. DV3/25659
Interconnection Cable Assembly	To WK Drg. DV2/25658

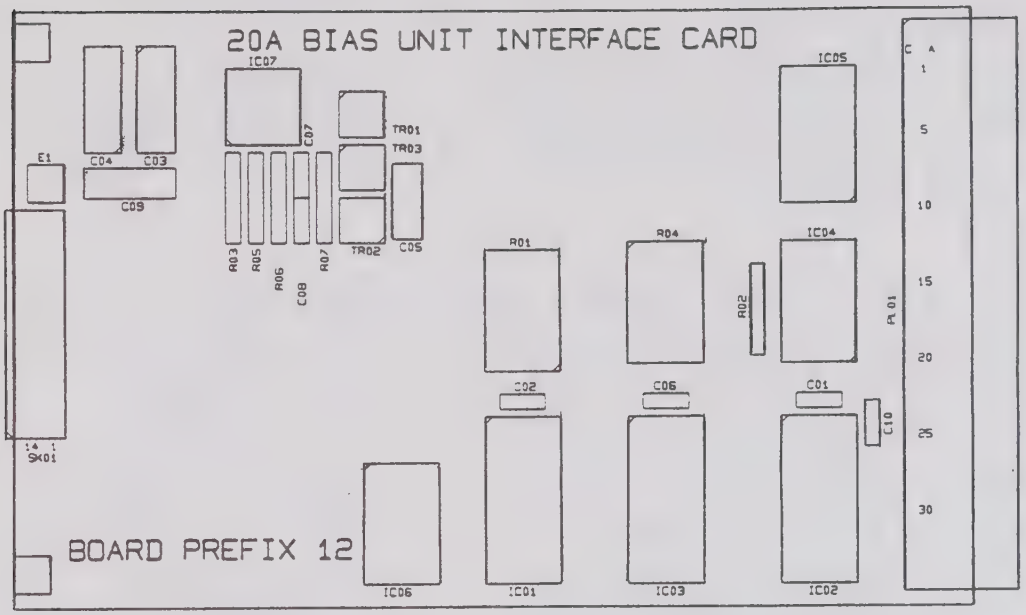


Fig. 11.1A Interface Card (Early version) - PCB Layout

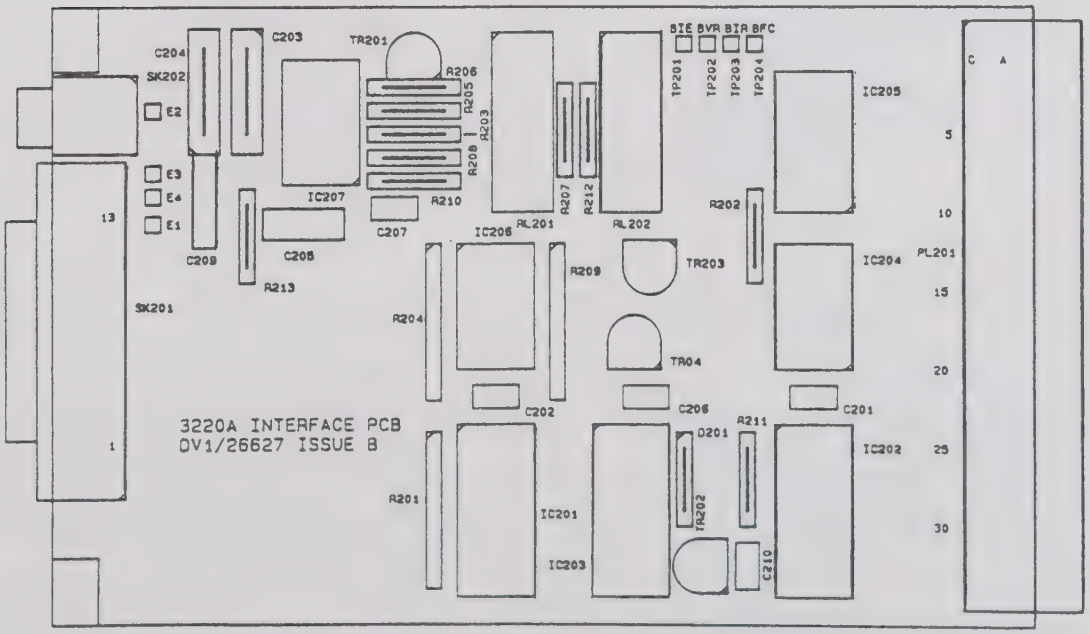


Fig. 11.1B Interface Card (Later version) - PCB Layout

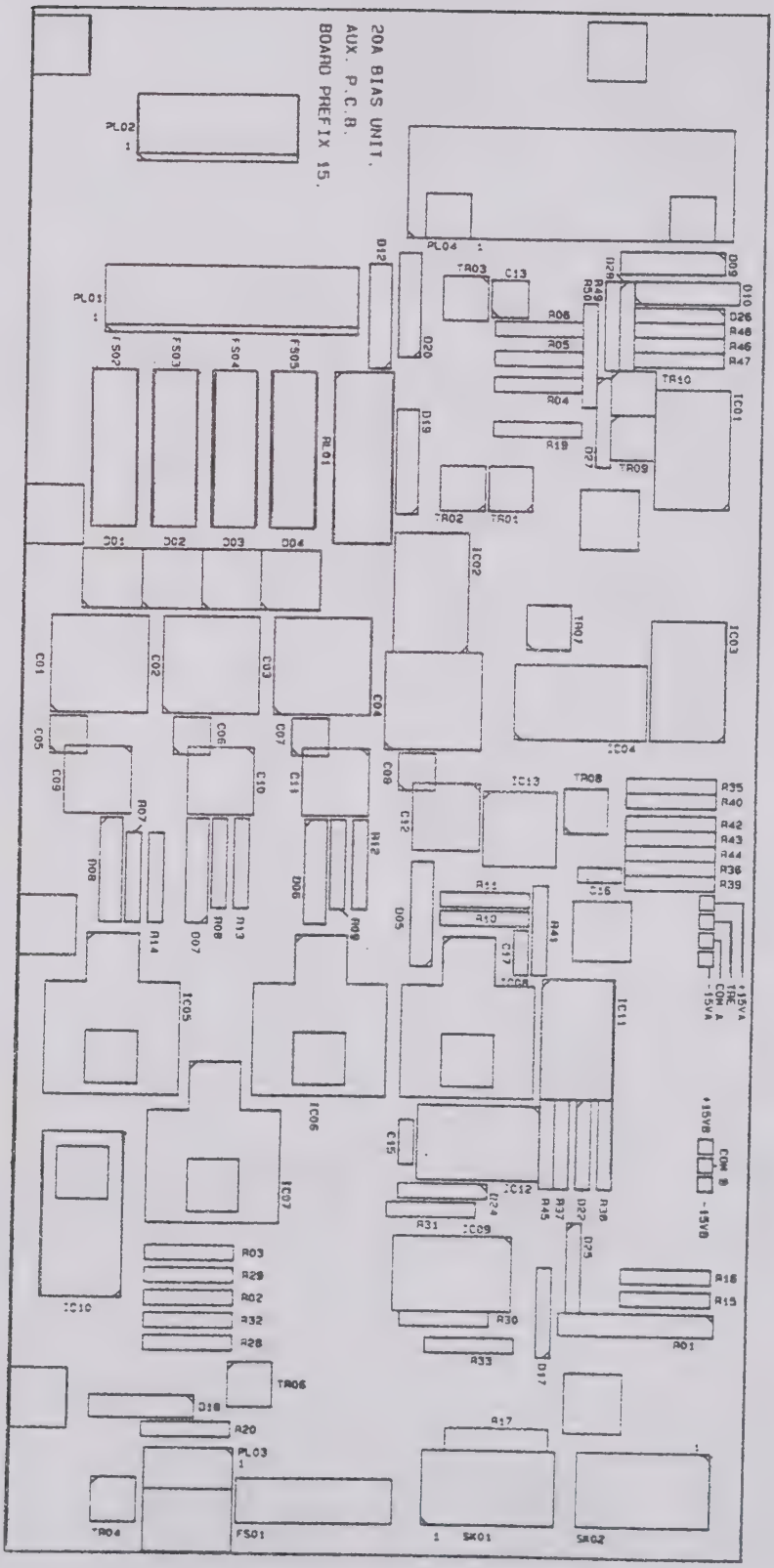


Fig. 11.3
Auxiliary Board
PCB Layout

Note Later models have R20 and TR04 replaced by Moxie temperature sensor TS1501, fitted to the "e" and "c" holes on the board.

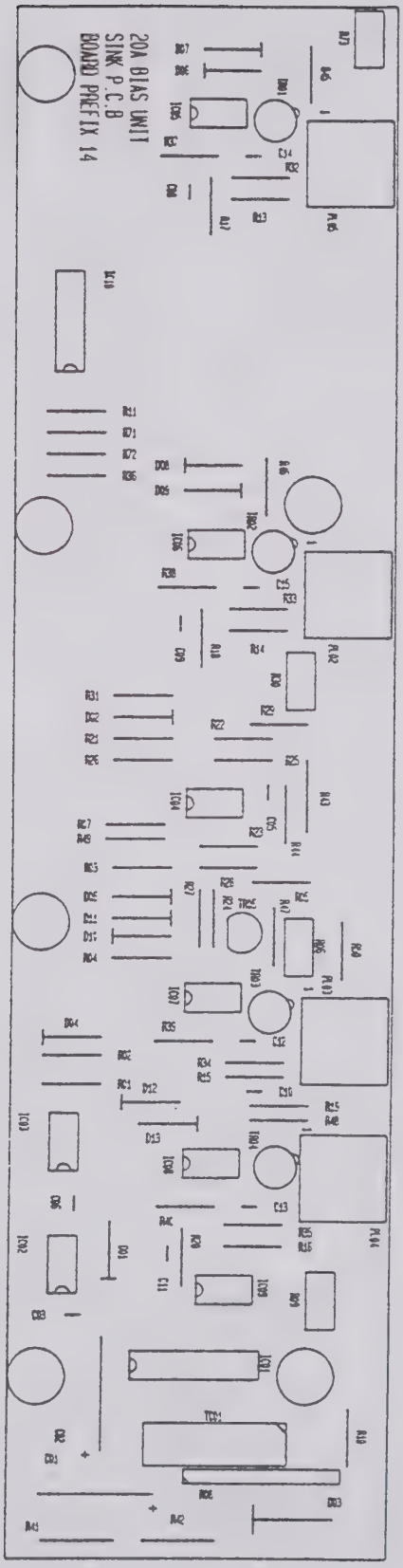


Fig. 11.5
Sink Board
PCB Layout

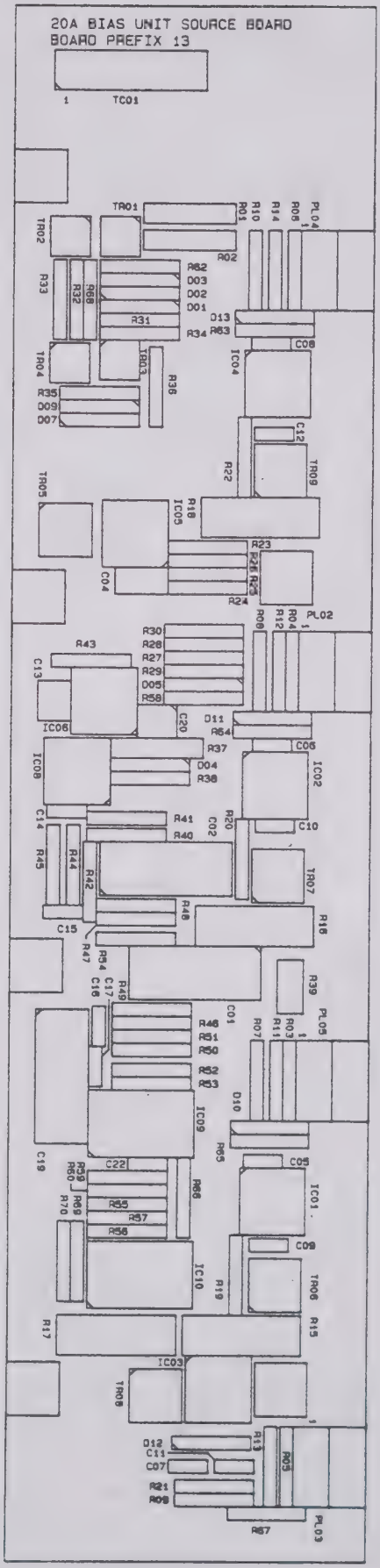
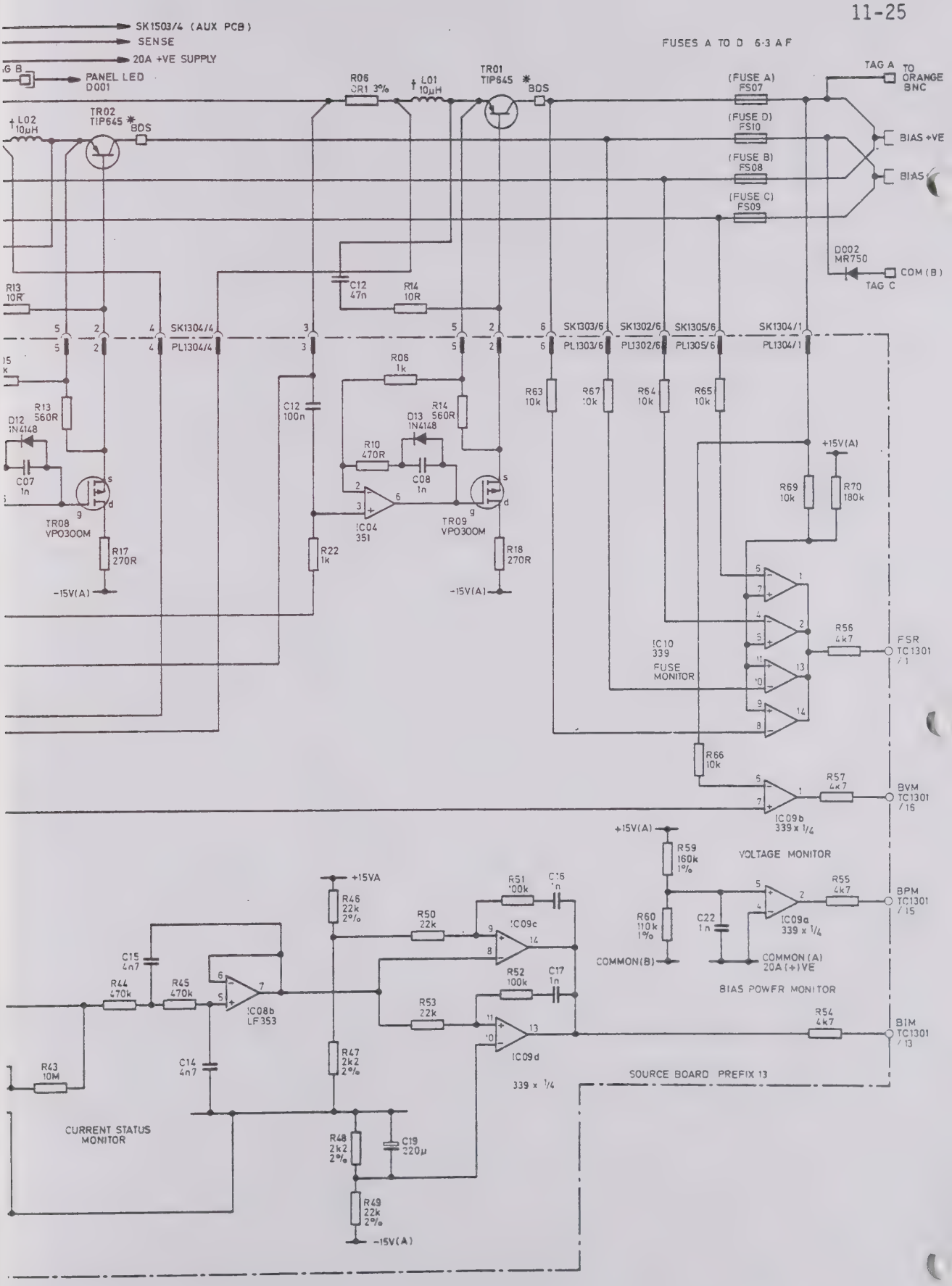


Fig. 11.7
Source Board
PCB Layout

COMPONENTS INSIDE CHAIN LINE ARE ON PCB AND CARRY PREFIX 13. OTHER COMPONENTS ARE ON HEAT SINK AND CARRY PREFIX 0

IC POWER CONNECTIONS		
IC	+VS	-VS
IC01–IC05	7	4
IC06, IC08	8	4
IC09, IC10	3	12

NOTE:
± 15V(A) SUPPLIES A
REFERENCED TO THE
(+)VE 20A SUPPLY (
COMMON (B) IS NORM
-3V TO GROUND
FUSE 'A' AT FRONT

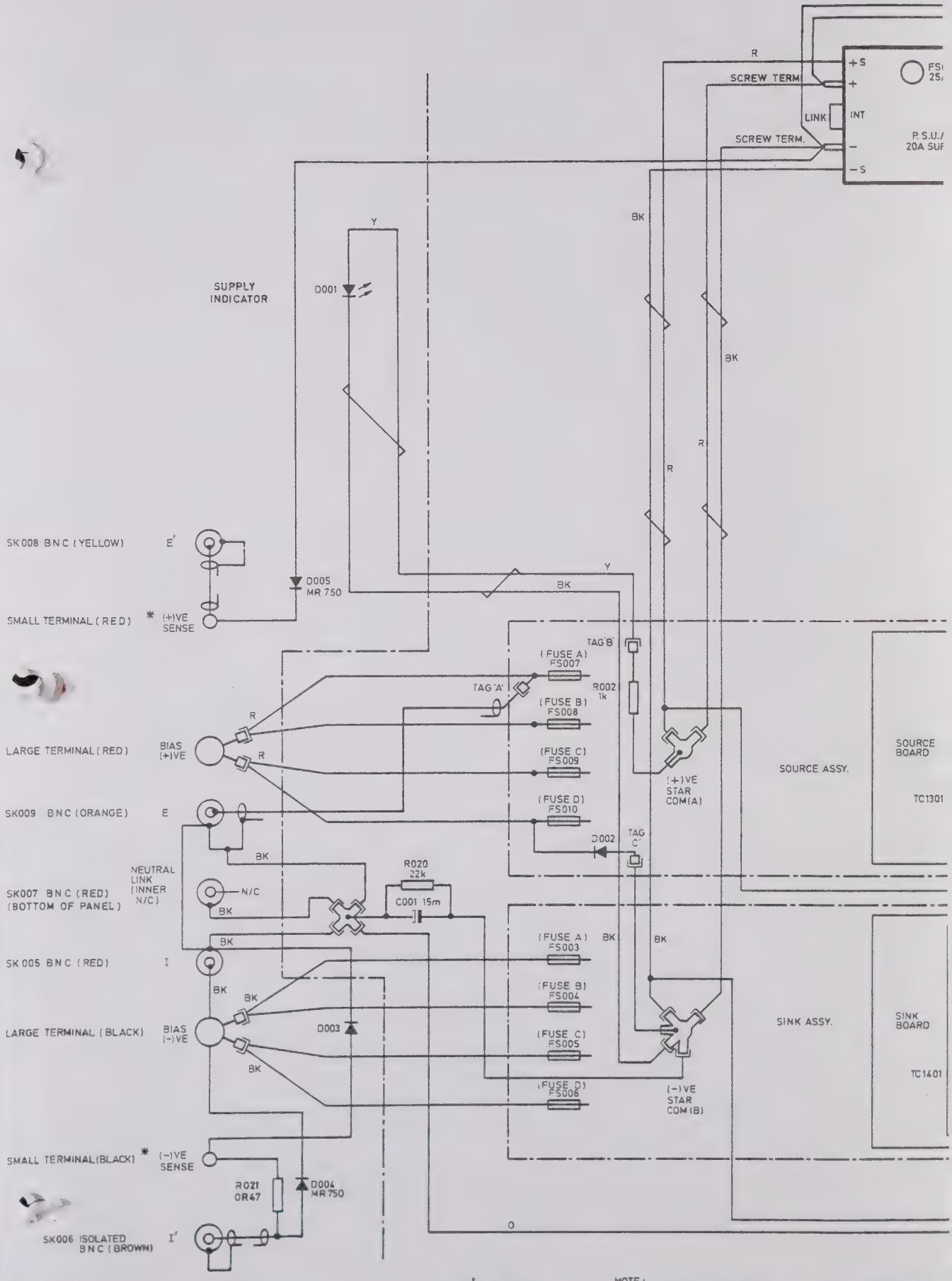


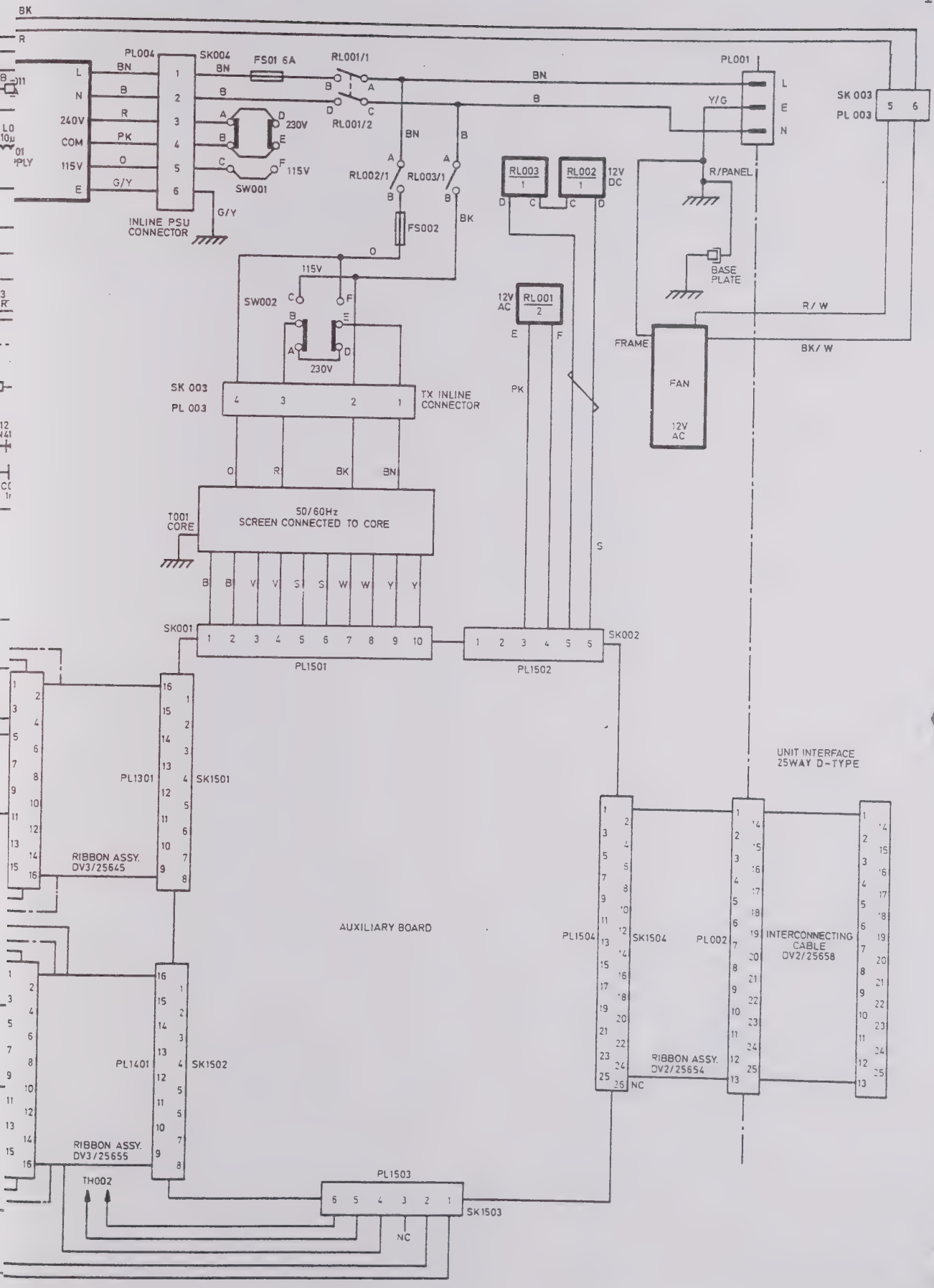
RE
INE. ALLY
OF UNIT

* BDS FX1115 FERRITE BEADS 5 OFF AT EACH POSITION

† ON EARLY MODELS, 10µH COILS REPLACED BY 5 FERRITE BEADS

Fig. 11.8 Source Board - Circuit Diagram (DV1/25613/P5)


R
SCREW TERM
+S
+
LINK
INT
SCREW TERM.
−
−S
P.S.U./
20A SUP
BK
Y
SUPPLY
INDICATOR
D001
BK
R
R
SK008 BNC (YELLOW)
E'
D005
MR 750
Y
BK
SMALL TERMINAL (RED)
*
(+)VE
SENSE
TAG 'B'
(FUSE A)
FS007
TAG 'A'
R002
1k
(FUSE B)
FS008
R
LARGE TERMINAL (RED)
BIAS
(+)VE
R
(FUSE C)
FS009
SOURCE ASSY.
SOURCE
BOARD
TC1301
(+)VE
STAR
COM(A)
SK009 BNC (ORANGE)
E
(FUSE D)
FS010
D002
TAG
'C'
BK
NEUTRAL
LINK
(INNER
N/C)
R020
22k
SK007 BNC (RED)
(BOTTOM OF PANEL)
N/C
C001 15m
BK
BK
(FUSE A)
FS003
BK
BK
SK005 BNC (RED)
I
BK
(FUSE B)
FS004
BK
D003
LARGE TERMINAL (BLACK)
BIAS
(−)VE
(FUSE C)
FS005
SINK ASSY.
SINK
BOARD
TC1401
BK
(FUSE D)
FS006
(−)VE
STAR
COM(B)
SMALL TERMINAL(BLACK)
*
(−)VE
SENSE
R021
0R47
D004
MR 750
O
SK006 ISOLATED
BNC (BROWN)
I'
DENOTES
PUSH-ON
TERMINAL
NOTE :
ALL BNC SOCKETS ARE
ISOLATED FROM CHASSIS.
THERMOSTATS TH001 AND
TH003 ARE NORMALLY OPEN,
TH002 NORMALLY CLOSED
SLIDE SWITCHES SHOWN
SET TO 230V POSITION.
* SENSE TERMINALS
LINKED AT BRIDGE.



CHASSIS DESIGNATED COMPONENTS PREFIXED 0

Fig. 11.9 Interconnections (DV1/25660/P6)

Support and Service

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Sandbeck Way,
Wetherby,
West Yorkshire,
LS22 4DN

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Fax 0937 586908 Sales
Telex 557294

Tel 0937 585215 Service
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Fax 617 933 9523
Telex 6817257

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D6050 Offenback/Main,
Frankfurt,
West Germany

Tel 069 810778
Fax 069 8002249
Telex 4185470

Ferrite - L_S

Laminated - L_P

Leakage - L_S